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Infusing Unplugged Computational Thinking into a Probability Worksheet for Students' Mathematical Literacy

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ABSTRACT

Objective: This research aims to: 1) develop a worksheet that incorporates unplugged computational thinking (CT) to support the strengthening of mathematical literacy; 2) test the validity, practicality, and effectiveness of the worksheet. **Method:** This study employed a development research design involving teachers, students, and experts. Data collection was conducted through literature review, observation, questionnaires, documentation, and a mathematical literacy test. Data analysis was conducted using qualitative and quantitative methods. **Results:** Based on the research results, the following results were obtained: 1) The CT-infused worksheet was designed to support the achievement of three learning objectives: students can determine sample points, determine probability values, and use these concepts in problem-solving; the worksheet contains learning activities that integrate CT and learning activities that support mathematical literacy; 2) The content validity index was 1, thus the worksheet is valid; Practicality tests by teachers and students yielded scores of 3.95 and 3.58, respectively, indicating that the worksheet is suitable for use as a support for mathematics learning. The trial results also demonstrated that these CT-infused worksheet is effective in improving students' mathematical literacy. **Novelty:** In contrast to earlier studies that focused on literature review, analysed students' CT abilities, or integrated CT into mathematics learning to improve CT abilities, this study integrates unplugged CT into a worksheet to improve junior high school students' mathematical literacy. This CT-infused worksheet has been proven valid, practical and effective as a probability teaching material to support the development of mathematical literacy.

INTRODUCTION

The development of the times requires that students acquire the skills required to navigate both the professional sphere and social life in the future. A wide range of jobs require mastery of mathematics and science, and the demand is predicted to increase (Martin & Mullis, 2017). These skills must be developed in schools (Mullis et al., 2011). Evaluation of these skills has been carried out in various countries and organizations, allowing the school curriculum to be continually reviewed in light of the development and needs of the times.

The results of the Programme for International Student Assessment (PISA) survey conducted by the Organisation for Economic Co-operation and Development (OECD) indicate that the mathematical literacy of Indonesian students remains low. Based on the PISA results reports from 2012, 2015, and 2018, even the 2018 results are lower than those of the previous period (OECD, 2014, 2016, 2018). The maths literacy or numeracy of Indonesian students is still below the international average. Additionally, the 2011 Trends in International Mathematics and Science Study (TIMSS), in which Indonesia participated, also reported similar findings. Of 42 countries, Indonesia ranked 38th in mathematics achievement (Mullis et al., 2011). These results have motivated the

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Indonesian Ministry of Education to evaluate the literacy skills of Indonesian students through the Minimum Competency Assessment (AKM) since 2021. Through this AKM, the Indonesian Ministry of Education aims to assess students' reading literacy and mathematics literacy, also known as numeracy, in order to enhance the quality of learning in each school. The 2022 AKM results indicated that the mathematical literacy of junior high school students in Indonesia fell into the medium category, with only 40.63% of students able to achieve the minimum competencies (Kemdikbud, 2023). This figure is only slightly above the threshold of the deficient category, which is 40%. Student achievement in probability content was reported to be lower than in others (Maulidiyah et al., 2024). According to Maharani et al. (2022), students' mastery of probability is not optimal, and various learning obstacles are identified, including misconceptions in solving probability problems. One of the efforts to improve mathematical literacy is to strengthen students' problem-solving skills (Temel & Altun, 2022).

On the other hand, one effective problem-solving strategy is computational thinking (CT). This does not require students to think like computers; instead, the students can focus on solving problems efficiently (Wing, 2006). Furthermore, Wing (2006) states that CT makes seemingly intractable problems into problems with known solutions. This skill is important for students, not solely for those interested in computer science and mathematics (Li et al., 2020). Dong et al. (2019) described the PRADA framework, four components of CT in K -12 learning, namely: 1) pattern recognition: identifying patterns, trends, and regularities in data, processes, or problems; 2) abstraction: identifying what is important and relevant to the problem; 3) decomposition: breaking down data, processes, or problems into smaller meaningful parts, and organising those parts; 4) algorithms: developing steps to solve similar problems or issues. Winthrop et al. (2016) proposed a taxonomy for integrating CT in mathematics and science learning in secondary schools. For instance, in learning probability, data collection can involve throwing coins or dice; data analysis can involve analysing the results of coin or dice throwing; data representation can involve sets, lists, or graphs containing data; and abstraction can involve identifying important facts from word problems (Barr & Stephenson, 2011). Moreover, integrating CT in school can enhance skills in mathematics, science, and literacy (Love et al., 2022).

The integration of CT in learning has been widely developed. CT is not equated with programming and is thus possible to be incorporated into the classroom (Rey et al., 2021). Teachers can integrate CT in learning through plugged activities, unplugged activities, or a combination of both (Chen et al., 2023). From the study by Suparman et al. (2024), several studies have integrated CT through unplugged activities in learning. Teachers can carry out unplugged activities in various ways, one of which is using a student worksheet (Rodriguez et al., 2017). In understanding the concepts of the subject matter, device-free activities prevent students from being distracted by applications. This activity also enables students to progress from simple to more complex concepts (Yuliana et al., 2021). Unplugged CT is also suitable for implementation before teachers plan lessons that involve much technology, as it requires a lower cognitive load. In this way, teachers can reduce initial barriers to learning (Arjona-Aranda et al., 2025). According to Uscanga et al. (2024), unplugged CT can increase student engagement in class and enhance the learning experience through problem solving, collaboration, and perseverance.

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Many studies have examined CT in learning and analyzed the results from various aspects, including Sukirman et al. (2024). In addition, Mufidah & Majid (2024) have also researched the influence of CT on numeracy skills through coding; however, the results have not been optimal due to several factors, including the limited mastery of technology and computer applications. Therefore, unplugged CT may be an alternative. Furthermore, several researchers have conducted studies highlighting the positive impact of integrating unplugged CT into mathematics learning, such as making it challenging and enjoyable, as well as motivating students to learn (Mumcu et al., 2023). Even How & Looi (2018) have modelled students' decision-making abilities in unplugged CT activities. Nevertheless, limited attention has been given to the development of unplugged CT-integrated teaching materials specifically designed to enhance students' mathematical literacy. This gap highlights the need to explore how CT-based approaches can be effectively integrated into mathematics instruction to address the challenges of preparing students with 21st-century competencies. Fostering mathematical literacy through CT-based approaches can provide both theoretical advancement and practical guidance for mathematics education. This study aims to develop a CT-integrated probability worksheet to support the mathematical literacy of junior high school students and to evaluate the validity, practicality, and effectiveness of the developed worksheet.

RESEARCH METHOD

This article describes the process of developing a worksheet within a comprehensive development framework utilising the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). This development model is applicable for creating teaching aids (Idris & Rus, 2023). The analysis stage involves identifying the needs of students, teachers, and the curriculum. This stage was conducted to determine the teaching materials needed in schools, the extent to which CT was applied in learning, and the teachers' efforts in developing students' mathematical literacy. At this stage, learning objectives are also formulated as a foundation for developing the worksheet (Davis, 2013). At the design stage, the researcher determined the worksheet outline and framework for worksheet activities based on the CT components, as outlined by Dong et al. (2019), and worksheet activities in accordance with the mathematical literacy framework of Puspenjar et al. (2021). At this stage, validation sheets, practitioner and student assessment sheets, and a mathematical literacy test were also prepared. The development stage involved creating a worksheet prototype, testing its validity, and evaluating its practicality with teachers and students. According to Aldoobie (2015), the evaluation stage is carried out in two types: evaluation at each stage and final evaluation to assess the effectiveness of the product. This research was evaluated at each stage before the worksheet prototype test in the broader field. Ultimately, the worksheet was tested in the experimental class to evaluate its effectiveness at the final stage.

The subjects of this research consisted of teachers, students, and experts. Data collection techniques were employed through observation, interviews, literature reviews, documentation, questionnaires and test tailored to the needs of each stage. The analysis stage employed observation, literature review, and interviews with teachers to gather qualitative data; the design stage utilised documentation techniques, while the development stage employed documentation techniques and questionnaires for experts, user teachers, and students. A total of 3 experts assessed the validity of the worksheet prototype. To test the feasibility of the worksheet before using it in the classroom, the worksheet prototypes were assessed by both teachers and students. A total of four teachers evaluated the practicality of the worksheet prototype, and four students assessed the feasibility of the worksheet as a learning support medium. After being declared valid and suitable for use, the worksheet was tested in the experimental class to be compared with the control class. This trial involved 29 junior high school students from a private school with an age range of 13-14 years. The groups were drawn from intact classes provided by the school, and therefore, no random assignment was applied. The sample consisted of 17 students in the experimental group and 12 students in the control group, who consistently participated in the learning process and took the mathematical literacy test. Data were collected through written tests administered to students in both groups.

Data analysis employed both qualitative and quantitative methods tailored to the characteristics of the development stage. At the analysis stage, data from observations, literature reviews, and informal interviews were qualitatively analysed in a descriptive way. This analysis was used to obtain an overview of existing teaching materials and classroom practices, which then served as the basis for developing the CT-integrated probability worksheet. At the design stage, the targeted output was the worksheet framework, student activity framework, and research instruments. During the development stage, the worksheet framework and activities were refined into a worksheet prototype, which was then tested for validity by experts, practicality by teachers, and feasibility by students. The validity of the worksheet was calculated using the Content Validity Index (CVI), as described by Yusoff (2019). Because this research involves three experts, the CVI must be 1, meaning that all experts must assign a score of 3 or 4 to each item. The practicality and results of the assessment by students were analysed using Azwar's criteria (1996). Qualitative data from expert input, teachers, and student ratings were used as the basis for evaluating and revising the worksheet prototype. The ultimate objective of this development stage is to produce a worksheet prototype that is valid, practical and feasible for use in mathematics instructions. Subsequently, the prototype was implemented in the experimental class. In the evaluation stage, data analysis employed the Mann-Whitney test because the sample size for each class was less than 30.

RESULTS AND DISCUSSION

Results

This study developed a worksheet prototype that presents learning activities by integrating unplugged CT, which comprises four components: pattern recognition, abstraction, decomposition, and algorithms. The worksheet was designed to support students' improvement in mathematical literacy. Following the development of the prototype, assessments were conducted by experts, teachers, and students to ensure the worksheet's feasibility and readiness for use in classroom learning. In the final stage, the prototype was tested in an experimental class to assess its effectiveness. A description of each stage and its results is presented as follows.

Creating Worksheet Prototype: Analysis

The development of this CT-infused worksheet commences with the analysis stage. One of them is related to curriculum analysis in junior high school, which is done through

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book literature studies and interviews with mathematics teachers. Based on observations at school and interviews with teachers, students do not yet have access to teaching materials related to mathematics literacy. In addition, most of the problems in the teaching materials that students learn are still routine, making them suboptimal for improving mathematical literacy. The literature study was conducted on junior high school mathematics books and references related to mathematical literacy and CT. This step is crucial to ensure that the worksheet aligns with the needs of teachers and students at school. From the results of the research, the learning objectives targeted in this worksheet are 1) enabling students to properly determine the sample point and sample space from the data presented appropriately, 2) allowing students to determine the simple probability problem appropriately, and 3) promoting students to solve contextual problems related to probability accurately.

Creating Worksheet Prototype: Design

During the design stage, the researcher developed the worksheet framework and the worksheet activity framework. The worksheet developed will contain a home page, a core page, and a bibliography. The home page features the cover, foreword, table of contents, a brief overview of worksheet information, instructions for use, learning objectives, and a concept map. The core page is divided into three, namely "*LKPD Pengantar Peluang*" (introduction to probability worksheet), "*LKPD Peluang Sederhana*" (basic probability worksheet), and "*LKPD Beragam Peluang*" (various types of probability worksheet).

On the general information page of the worksheet, researchers presented a framework of information on mathematical literacy and CT, expressed in language that is easily understandable to both teachers and students. Regarding the core activities, the worksheet activity design process involved preparing a grid of student activities that considered the components of CT and mathematical literacy. The worksheet included CT integration in various unplugged activities, as shown in Table 1 below.

Table 1. CT integration (Dong et al., 2019) in unplugged activities

Component	Activity on the Worksheet
Pattern recognition	"*Ayo Mengenali Pola!*" (meaning "Let's Recognise Patterns!") facilitates students to identify patterns or problems based on previously acquired concepts. For example, students identify the sample point and sample space of candy in a bag after reviewing the dice and coins problem.
Abstraction	"*Abstraksi*" (meaning "Abstraction") helps students identify important information in contextual problems. Additionally, the worksheet helps students record important information about the problem before attempting to solve it. For example, students identify the players in the werewolf game problem.
Decomposition	"*Ayo Mendekomposisi Masalah!*" (meaning "Let's Decompose the Problem!") helps students break down the problem into simpler ones. For example, when determining the probability of drawing a bridge card, students break down the solution process into smaller parts
Algorithms	Worksheet facilitate students in developing problem-solving algorithms. For example, "*Ayo Menyimpulkan!*" (meaning "Let's Conclude!") facilitates students in developing an algorithm to determine simple probability.

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The design stage produced a grid related to mathematical literacy in the worksheet, as shown in Table 2 below.

Table 2. Mathematical literacy-numeracy (Puspenjar et al., 2021) on the worksheet

Cognitive Level	Activity on Worksheet
Knowing	"*Ayo Memahami!*" (means "Let's Understand!") facilitates students in: (a) identifying sample points and sample spaces by taking information on the case of throwing dice in a snakes and ladders game; (b) identifying sample points and sample spaces by taking information on the case of bags of candy; and (c) calculating the probability of a simple event of throwing a dice; (d) identifying the probability of an event of throwing several currency coins.
Applying	"*Ayo Menerapkan!*" (means "Let's Apply!") facilitates students in: (a) applying the concepts of sample points and sample space in answering questions related to players in a game; (b) applying the familiar concept of probability in answering questions related to the problem of picking bridge cards; (c) applying the familiar concept of probability in answering questions related to the problem of picking the throw of two dice.
Reasoning	"*Ayo Menalar!*" (means "Let's Reason!") facilitates learners in: (a) inferring the truth value of a statement based on information and facts in the case of a more complex werewolf game; (b) analysing the data presented for the context of the probability of the appearance of numbers with more complex questions; and (c) analysing the probability related to more complex dice and coin combination problems.

Creating Worksheet Prototype: Development

The development stage involves refining the worksheet framework determined during the design stage, followed by expert, teacher, and student assessments. At this stage, a cover page is designed to align with the characteristics of the worksheet, containing computational thinking and probability symbols. In the 'Information at a Glance' section of the worksheet, this page presents a description related to the characteristics of mathematics-numeracy literacy, specifically about the context of the problem and its cognitive level. It also offers an overview of CT within the learning activity; and introduces the fundamental concepts of probability.

The development of student activities was based on the grids in Tables 1 and 2 above. For example, the first worksheet, which is an introductory probability worksheet, presents the context of a Snakes and Ladders game, as shown in Figure 1.

To enhance mathematical literacy, the worksheet was designed in accordance with the characteristics of cognitive processes in mathematical literacy-numeracy developed by Puspenjar et al. (2021). The activity on the worksheet includes an "*Ayo Memahami!*" section that is based on the knowing indicators of mathematical literacy. This activity bridges the gap between the problem presented in the introduction and the subsequent mathematical content. The worksheet also includes an "*Ayo Menerapkan!*" activity to help students apply their mathematical knowledge in problem-solving. In addition, the worksheet also includes an "*Ayo Menalar!*" activity that facilitates students in analysing data to conclude.

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Ayo Membaca!

Ular Tangga

Apakah kamu mengenal permainan ular tangga? Permainan ular tangga adalah permainan papan yang dimainkan oleh dua atau lebih pemain. Papan permainan terdiri dari kotak-kotak yang diurutkan dalam baris-baris horizontal dan vertikal. Di dalam permainan ini, pemain bergerak maju melalui kotak-kotak tersebut dengan mengikuti nomor dadu yang dilemparkan. Dadu yang digunakan sebanyak satu buah.

Setiap pemain bergantian untuk melempar dadu dan menggerakkan pion mereka sesuai dengan jumlah yang tertera pada dadu. Tujuan utama dari permainan ini adalah untuk mencapai kotak terakhir di papan, biasanya kotak bernomor tinggi, yang menandakan kemenangan.

Namun, di sepanjang perjalanan, pemain dapat mengalami berbagai rintangan yang ditunjukkan oleh ular dan tangga yang menghubungkan beberapa kotak. Jika pemain mendarat di kotak ular, mereka harus turun ke kotak yang lebih rendah, sedangkan jika mereka mendarat di kotak tangga, mereka dapat maju ke kotak yang lebih tinggi.

Nah, dari sini kita akan mengenal istilah **titik sampel**, **ruang sampel**, dan peluang.

Figure 1. Introduction to Activities in the Introduction to Probability Worksheet

The "Abstraksi" activity in the worksheet provides students with the opportunity to identify information in the context of the werewolf game presented. In the "*Ayo Mengenali Pola!*" activity, students identify probability. They need to determine the sample space and sample points based on the concepts they learned from the previous "*Ayo Memahami!*" activity. Decomposition on the worksheet can be observed in the activity of decomposing the problem, which allows students to identify the sample space into several parts, each comprising a set of sample points. In the "*Ayo Mendekomposisi!*" activity, students identify each of the many sample points of the overall sample space in the case of the werewolf game. Meanwhile, the algorithm activity is integrated into the summarizing activity, where students have to compile the steps of the problem-solving algorithm.

After development, experts, user teachers, and students assessed the worksheet to test the validity, practicality, and feasibility. Validation involved three experts in the field of mathematics education or computational thinking. This process aims to assess whether the developed worksheet is valid in terms of content, language, and visual appeal. The content aspect consists of 11 statement items, the language aspect consists of 4 statement items, and the appearance aspect consists of 5 statement items. Each statement consists of 4 answer options with a score of 1 to 4. The results of the CVI calculation for each aspect are presented in Table 3. According to Yusoff (2019), the product is declared valid by three experts if the CVI score is 1. Therefore, the worksheet prototype developed is valid.

Table 3. The relevance ratings on the item scale by experts

Aspect	Average CVI
Content	1
Language	1
Worksheet display	1
Total average CVI	1

Users, namely teachers and students, assessed the feasibility of the worksheet prototype. The user teacher assessed the practicality of the worksheet, while the students' perspective is mandatory as they are the end-users of the developed products. In general,

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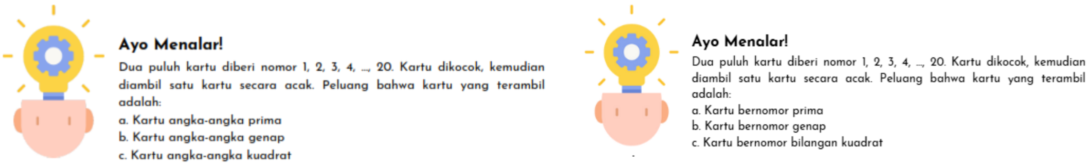
the teacher evaluates the suitability of the school curriculum and student characteristics, the usefulness of the worksheet, and the feasibility of the worksheet as a learning medium. The practicality instrument used a questionnaire with a 1-4 Likert scale. Details of the teacher's assessment of the worksheet's practicality are presented in Table 4. Based on the analysis of this data, it is evident that the worksheet prototype is declared practical with a score of 3.95.

Table 4. Teacher's practicality assessment

Aspect	Practicality Score
Usefulness to support learning	3.90
Suitability with the school curriculum	4
Suitability with student characters	3.92
Feasibility of display as learning media	4
Average practicality	3.95

Teachers also provided input on the readiness of the prototype for classroom use, which was used to revise the worksheet. For example, as depicted in Figure 2, the teacher suggested modifying the question sentence to fit the context of the problem. In the initial draft of the worksheet, it was written "prime numbers card", whereas the context of the problem was related to cards numbered with primes.



Before revision **After revision**

Figure 2. Example of worksheet revision based on user teacher feedback

Additionally, students also assess the feasibility of the worksheet prototype from the aspects of ease of use, attractiveness, and usefulness in learning. As end-users of the worksheet, students can provide valuable feedback on the suitability of the worksheet to their individual needs and characteristics. Students evaluate the readiness of the worksheet using a questionnaire with 12 statement items on a scale of 1-4. The results of the student assessment are presented in Table 5, where the worksheet was deemed feasible with a score of 3.58. Students also provided feedback on the worksheet, perceiving it as enjoyable and the pictures as motivating for learning. On the other hand, they also provided input related to the less spacious work area and the presentation of questions on a single page.

Table 5. Assessment of the worksheet by students

Aspect	Score Practicality
Ease of use	3.55
Attractiveness	3.875
Usefulness to support learning	3.5
Average student assessment	3.58

Implementing and Evaluating Worksheet

The resulting prototype was implemented in mathematics learning in a seventh-grade junior high school. This stage was conducted to assess the product's effectiveness. The

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trial involved two classes: an experimental class and a control class. In the experimental class, the learning incorporated a CT-infused worksheet. Meanwhile, in the control class, the teacher used a regular worksheet to teach probability. At the end of the lesson, both classes were evaluated using a mathematical literacy test. Student work results were processed using the Mann-Whitney Test, as shown in Table 6 below.

Table 6. Mann-Whitney test results for both classes

Ranks				
	Class	**N**	**Mean Rank**	**Sum of Ranks**
Mathematical literacy test results	Math class with CT-infused workheet	17	17.65	300.00
	Math class with a regular worksheet	12	11.25	135.00
	Total	29		

Test Statistics	
	Mathematical literacy test results
Mann-Whitney U	57.000
Wilcoxon W	135.000
Z	-2.008
Asymp. Sig. (2-tailed)	.045
Exact Sig. [2*(1-tailed Sig.)]	.048[a]
a. Not corrected for ties	
b. Grouping Variable: class	

The analysis results show an asymptotic significance value of $0.045 < 0.05$, indicating a significant difference between the mathematical literacy test results in classes with CT-infused worksheet and classes with regular worksheet. This is also supported by the exact significance value of $0.048 < 0.05$. The table shows that the mathematical literacy performance of students in classes with CT-infused worksheet (mean rank 17.65) is better than that of students in classes with regular worksheet (mean rank 11.25). Thus, this CT-infused worksheet is proven effective.

Discussion

Our study provides students with a CT-infused worksheet that has three learning objectives: students can specify sample points, determine probability values, and use these concepts in problem-solving activities. These objectives reflect how CT can be integrated into probability content while still emphasizing the focus of mathematics learning, namely problem solving (Astuti et al., 2023). To support students' mathematical literacy, particularly in the context of knowing activities, students are asked to identify the dice and coin to comprehend the concepts of sample points and sample space. The application skills are developed through the "*Ayo Menerapkan!*" activity, where students apply the concepts they learn to solve routine problems. Meanwhile, reasoning ability is pursued through activities that demand the ability to analyse more complex information and data. This implies that the worksheet design not only contains mathematical content, but also directs students to improve mathematical literacy.

The resulting product integrates CT components across several worksheet activities. The abstraction component enables students to identify important points in the problem, which aligns with Azma et al. (2024), who suggest that abstraction requires students to focus on the core information. Similarly, for other CT components, this integrated design aligns with their research. However, they explicitly listed these components as part of their worksheet. Meanwhile, the worksheet developed in this research presents them implicitly through activities. A CT-based worksheet was also developed by Kurniasi et al. (2022), who integrated CT into the content of algebraic function derivatives. Besides explicitly mentioning the CT components in the worksheet as Azma et al. (2024) did, Kurniasi et al. (2022) integrated slightly different CT components: abstraction, generalization, decomposition, algorithmic, and debugging; and also designed these components as an irreversible sequence. Meanwhile, the developed worksheet in this study utilises the CT components offered by Dong et al. (2019) and does not consider them as sequential in problem-solving.

The data demonstrate that this worksheet is valid with an average CVI of 1 due to its alignment with the school curriculum, CT indicators, and mathematical literacy indicators. In addition, the accuracy of language use and the accuracy of the worksheet display are also considered valid. However, there are still aspects that require attention, as several validators gave a score of 3 (on a scale of 4) for several items. Experts indicated that contextual alignment with cultural, scientific, and personal dimensions could be further optimised, which would strengthen its relevance to students' daily experiences. Furthermore, the item related to sufficient space for students to write down ideas also needs to be optimised. This evaluation aligns with Rahmi's (2023) research, which involved experts assessing online worksheets before use. However, Rahmi (2023) involved two media experts to evaluate the online worksheets and two material experts to assess the worksheets' suitability for didactic, construction, technical, and material quality aspects. Our study did not involve media experts specifically because we developed unplugged media that had been evaluated by 3 experts in the field of mathematics education and CT in education.

Another finding is that the practicality of the worksheet showed a score of 3.95, indicating that the CT-integrated probability worksheet was highly practical for classroom use. Unlike Kurniasi et al. (2022), who evaluated worksheets using a 5-point Likert scale and converted them into percentages, this study analyzed them based on Azwar's criteria (1996). However, the components evaluated by teachers were almost identical: content, construct, language, time allocation, and working instructions. Teachers evaluated that the worksheet was fully aligned with the school curriculum and feasible to implement as a learning medium. Nevertheless, the practicality could still be optimised, particularly in supporting learning (score 3.90) and in matching with student characteristics (score 3.92). The part that could still be optimised is the design of CT-related activities, as some teachers gave a score of 3 for the suitability of the abstraction and pattern recognition activity designs as probability learning media. the use of language that suits the characteristics of junior high school students should also be taken into consideration. Based on student responses, the practicality score was 3.58. This worksheet is practical because it is attractive, the instructions are clear, the problems presented are understandable, and the activity design supports problem-solving. From

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the student's perspective, some areas that need improvement are the details of CT activities on the worksheet and the lack of workspace. The above findings point out that the CT worksheet is suitable for use in classroom learning.

Ultimately, the effectiveness test revealed a significant difference in mathematics literacy skills between the experimental and control classes. The higher mean rank in the experimental class compared to the control class indicates that students learning with unplugged CT-infused worksheets have better mathematical literacy skills. Unlike Afif & Titikusumawati (2022), they employed a one-group pretest–posttest design with 34 students to assess the effectiveness of learning that integrates unplugged CT in improving problem-solving skills. Meanwhile, this study involved only 29 students, 17 of whom used CT-infused worksheets, while the rest did not. However, all students followed the entire series of probability learning and took a mathematical literacy test. This is relevant to Santeri et al. (2024) who demonstrated that plugged CT integration was effective in improving the logical thinking skills of junior high school students. Our finding reveals that unplugged CT integration has also been shown to improve mathematical literacy.

Through the developed CT-integrated worksheet, students are expected to develop mathematical literacy. Not only is CT introduced to students, but this worksheet also focuses on improving students' mathematical literacy. As described by Puspenjar et al. (2021), the cognitive levels that students must master are knowing, applying, and reasoning. In arithmetic, knowing involves written computation, applying is related to word problems, and reasoning involves arithmetic reasoning (Zhang et al., 2017). According to Martin and Mullis (2017), prior to applying and reasoning about mathematical situations, students must first develop an understanding of the fundamentals, including core mathematical concepts and properties. This worksheet also presents a step-by-step activity that encourages students to know, apply, and reason with the intention that they can gradually use mathematics for everyday problem-solving.

CONCLUSION

Fundamental Finding : The development of CT-infused probability worksheets to support students' mathematical literacy begins with a needs analysis to determine learning objectives, including the application of probability concepts for problem-solving. Experts stated that the worksheet was valid; teachers evaluated its practicality, and students assessed its feasibility. The final evaluation demonstrates that this worksheet has been proven effective in supporting students' mathematical literacy. **Implication :** This research contributes to: (1) demonstrating the integration of CT in mathematics learning worksheet that have been proven valid, practical and effective in improving mathematical literacy, and (2) providing teaching materials for teachers to support strengthening students' mathematical literacy through infusing CT in learning. **Limitation :** Despite its contributions, this research has limitations, namely (1) the sample for the effectiveness trial of the research is still limited to one school with fewer than 30 students; (2) the product implementation stage was carried out in a limited period so that the sustainable impact on mathematical literacy has not been studied; and (3) the product was developed only for probability content. **Future Research :** Further research is recommended to: (1) test the product in a broader sample with a larger number of students, (2) develop worksheet for other mathematics learning contents to extend the

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implementation period in mathematics learning, thereby enabling the sustainable impact of CT-infused worksheet on mathematical literacy to be examined.

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