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The Development of Computational Thinking Skills Science E-Worksheets for PGMI Students at PTKIN

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ABSTRACT

Science teachers are involved in the formation of quality human resources. As the times develop, technology is developing rapidly and computational thinking skills are also needed. The purpose of this study is to develop Computational Thinking Skills-based E-Worksheets for PGMI students. The research method uses ADDIE development which consists of five stages of Analyze, Design, Develop, Implement, Evaluate. The subjects of the study are PGMI students in 3 PTKIN, namely UIN Maulana Malik Ibrahim Malang, UIN Kudus, and UIN Mataram. Data collection techniques with observation, interviews, tests, and questionnaires. The data analysis technique uses the independent sample t-test to compare the improvement of student learning outcomes and the Anova Test to compare the differences between PTKIN. The results of the study showed that the learning outcomes in each PTKIN have increased, as shown by the value of sig. all three are 0.000 < 0.05. Meanwhile, the results of the Anova test value sig. 0.042 < 0.05. So it can be concluded that the use of E-woksheets media science computational thinking in improving student learning outcomes, especially in science literacy.

Keywords: E-wokrsheet Science; Computational Thinking Skills; Development Computational Thinking Skills

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INTRODUCTION

Everyone must have the knowledge and ability to compete in the global market due to the rapid development of science and technology. An important skill that everyone must have is the ability to utilize technology to solve problems and understand science (science literacy) (Barus, 2022). Thus, science teachers are involved in the formation of quality human resources. Science means the systematic study of nature. Therefore, science is not just the acquisition of facts, concepts, and principles (Kusumawati, 2022). Students who will become science or science teachers must understand these important things.

Science learning carried out for PGMI students is an optional course, this is an in-depth development for PGMI students prospective teachers to develop their abilities in learning science learning concepts that will be used in elementary schools. The learning outcomes of students who take this course will have the ability to explain the basics of science education, learning theory and application of science, science learning methods and approaches, knowing the capabilities of the science education process, factors that affect the development of school science education identified, examples of science education development, etc.

E-worksheets are learning aids designed to help students understand the content of the lesson (Wicaksana & Natalia, 2023). *Worksheets* help students solve problems (Yunus & others, 2020). In addition, materials, summaries, and guidelines for the implementation of learning activities can be included in *the Worksheets* (Rambe et al., 2023). Therefore, *the Worksheets* are expected to help students to play a more active role in the lecture process. *Worksheets* help

students develop concepts about the material they are studying by doing activities and thinking more actively.

The rapidly developing technological phenomenon is also beneficial for the world of education. One of the technologies that can be used in the learning process is the use of *E-Worksheets* media which is a technological breakthrough in creating a more practical and effective learning process. *E-Worksheets* offer many benefits, including: Features such as easy access, practicality, and low cost make them an innovative option for educators to fully engage students. The provision of learning materials such as E-worksheets must be adjusted to the lecture strategy used in the classroom. An approach to learning that puts students at the center of learning is called computational thinking skills, and they are essential skills in the 21st century (Hunsaker, 2020; Usta & Mirasyedioglu, 2021), particularly when it comes to teaching science. It incorporates a number of cognitive processes that enable people to use methodical, logical reasoning to solve complex situations. Consequently, the significance of computational thinking abilities, their application in science education, and their benefits for teacher students is significant.

Integrating computational thinking into science education is an important strategy for developing essential skills needed in modern society. Computational thinking not only improves academic performance through promoting critical thinking and enhancing problem-solving abilities, and preparing students for technical challenges, but also helps students prepare for their future careers. As the educational framework continues to evolve, a focus on computational thinking will become vital to equip pupils to succeed in an increasingly complex digital world.

Based on the development of the times In the present day, as prospective teachers also need to understand thinking skills through technology. Especially in the science learning procedure, this skill is needed, therefore, in addition to being able to solve problems, students will also be trained to have critical thinking skills. As with the research conducted by (Rokhimawan, 2016) who developed process skills-based Worksheets for PGMI students of science courses, which stated that The study's findings demonstrated that the application of *Worksheets* media was in accordance with needs and the results of readability and clear suitability. So this research was carried out to overcome the problems that exist in lectures, especially PGMI study programs.

Considering earlier research studies, it can be concluded that the development of E-Worksheets has been carried out with a cooperative learning approach, science process skills, and problem solving. However, there have not been many studies that specifically develop Computational Thinking Skills-based E-Worksheets for PGMI students, especially in the context of science learning at PTKIN. Therefore, this Research aims to satisfy this gap by developing E-Worksheets that are not only valid and effective, but also integrated with computational thinking skills that are extremely pertinent to the requirements of the twenty-first century.

METHOD

The ADDIE methodology, which has five stages Analyze, Design, Develop, Implement, and Evaluate is used in this development study. The study's subjects are PGMI students of UIN Maulana Malik Ibrahim Malang, UIN Kudus, and UIN Mataram. The subject design uses Pretest and Posttest Experimental Design. The kind of information utilized in the research consisted of quantitative data, namely verification evaluation questionnaires from media, learning practitioners, and subject matter experts, media attractiveness evaluation questionnaire results, and test results in the form of pretest and posttest. Meanwhile, Observations, expert critique and recommendations, and student interviews are examples of qualitative data. Tests, questionnaires, interviews, and observation were employed as data gathering tools. To ascertain the degree of relevance, attractiveness, and efficacy of the usage, the research data analysis technique takes the form of pretest and post-test evaluation of E-Worksheets. The data analysis used is the validity of the product with the following formula.

$$P = \frac{F}{N} \times 100$$

Information:
P = Final Score
F = Score Gain
N = Maximun Score

An independent sample t-test was used to assess the efficacy of the computation of E-Worksheet media products, with the need of homogeneity and normality testing on each pretest and postet results in PTKIN. Meanwhile, the comparison of the increase for each PTKIN was analyzed using the Annova test using an SPSS-assisted application.

RESULT AND DISCUSSION

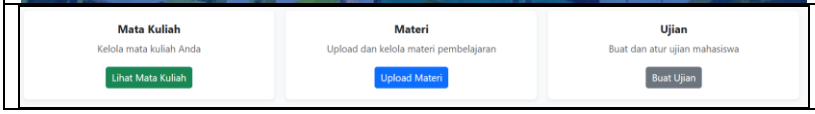
The E-Worksheets Computational Thinking Skills Science product, which enhances the learning outcomes of madrasah competence exams, is the outcome of this effort. Students have greater flexibility in using these e-Worksheets at different times and locations because they may be used on laptops and mobile devices. Students at PTKIN's Madrasah Ibtidaiyah Teacher Education specifically use this e-Worksheet. The five stages of the ADDIE development model are Analyze, Design, Develop, Implement, and Evaluate.

At the Analyze stage, the first step is to analyze needs, starting with identifying problems through interviews and observations of PGMI students at UIN Malang, UIN Mataram, and UIN Kudus. The results show that students still experience obstacles in understanding abstract science materials, lack of interactive and contextual learning media, and lack of references that are integrated with computational thinking skills. This has an effect on the absence of optimal learning outcomes, especially in facing the challenges of literacy, numeracy, and high-level thinking skills-based assessments. Furthermore, the analysis of the learning environment shows that the learning process of students has used learning aids such as laptops and the internet. Analysis of student characteristics shows that Madrasah Ibtidaiyah Teacher Education students at PTKIN generally have an interest in technology, especially at the level of smartphones which are also quite high, judging from the ownership and intensity of their use. The last step of the analysis stage is to analyze the learning objectives to identify the forms of learning activities that PGMI students should do in the Living Beings and the Environment course, in order for them to conform to the features of the science material that will be developed in the E-Worksheet-based learning media with computational thinking abilities such as algorithms, abstraction, pattern recognition, and decomposition.

The next stage is design, at this stage determine a learning strategy to help students in carrying out a meaningful learning process. The learning strategy used in learning Computational Thinking Skills for PGMI Students at PTKIN by providing material deepening and evaluation features in the form of problem-solving problems used for student independent learning. In addition, in this stage, also designing a storyboard design as an overview of the media to be developed, especially the appearance and content of the content itself which is made as attractive and easy to understand as possible in order to attract students' interest in learning and the display is made as attractive as possible with the aim of familiarizing students with the menu display in the LMS. For example, there is a question menu that includes Decomposition, Pattern Recognition, Abstraction and Algorithm as well as various menu buttons that have been adjusted.

The development stage is to develop and produce E-Worksheet products by developing interface design and developing material presentations. The display of E-Worksheet media is presented in Table 1.

Table 1. Media Develoment Results

Description	Display
	Logo Display
	Menu Home
	Media Content Menu

At the development stage, after the media is developed, a validation assessment stage is carried out to the validators, the assessment from material experts of 98% shows that the developed media is very valid. Media experts get a score of 96%, indicating that the developed media is very valid, Finally, the assessment from learning practitioners of 93% shows that the developed media is very valid. So that based on the assessment of the media validators, it is declared feasible and valid to be used,

After the media was developed and declared feasible, it was continued in the Implementation stage to PGMI students at UIN Maulana Malik Ibrahim University Malang, UIN Kudus, and UIN Mataram. At this stage, every student at 3 universities gets the same treatment, namely with pretest and postest. The independent sample t-test was used to compute the results and compare the study's findings at each University, while the comparison of learning outcomes between 3 universities used the Anova Test. However, before the measurement is carried out, the data obtained must go through a prerequisite test, namely normality and homogeneity. Table 2 displays the findings of the Shapiro-Wilk normalcy test.

Table 2. Normality Test Results for Each University

University	Sig.		Conclusion
	Pretest	Postest	
UIN Maulana Malik Ibrahim Malang	0.156	0.163	Normal
UIN Kudus	0.106	0.056	Normal
UIN Mataram	0.308	0.162	Normal

According to Table 2. We can deduce that each university's normalcy test results are deemed normal. The following test uses Levene's statistics, which are shown in Table 3, to determine homogeneity.

Table 3. Homogeneity Test Results of Each University

University	Levene Statistic	Sig.	Conclusion
UIN Maulana Malik Ibrahim Malang	0.015	0.902	Homogeneous
UIN Kudus	0.052	0.820	Homogeneous
UIN Mataram	2.049	0.159	Homogeneous

In light of Table 3. Based on the data collected from each university, it can be said that the data is uniformly dispersed. As a result, the independent sample t-test shown in Table 4 can proceed with the data.

Table 4. Result of Independent Sample T-Test Each University

University	F	Sig.	t	df	Sig. 2-tailed	Conclusion
UIN Maulana Malik Ibrahim Malang	0.015	0.902	4.846	48	0.000	Signifikan
UIN Kudus	0.052	0.820	7.809	48	0.000	Signifikan
UIN Mataram	2.049	0.159	8.153	48	0.000	Signifikan

Considering Table 4. We may conclude that the data is homogeneously distributed because the F value with the Levene Statistic result is the same and the Sig value for each of the three universities is more than 0.05. In the meantime, it can be concluded that learning outcomes have considerably improved because the tailed sig.2 value from the three colleges indicates that the sig value is less than zero. Additionally, the Annova test was performed to identify significant differences. However, prior to the homogeneity test, three universities listed in Table 5 were tested concurrently.

Table 5. Anova Homogeneity Test

Levene Statistic	df1	df2	Sig.
0.408	2	72	0.666

Table 5 demonstrates that the data collected from the three universities exhibit uniformity at the same time. The significant variations in increase shown in Table 6 were then compared using Anova testing.

Table 6. Anova Test Results

	F	Sig.
Between Groups	3.307	0.042

The three groups of PGMI students at UIN Maulan Malik Ibrahim Malang, UIN Kudus, and UIN Mataram had significantly different learning outcomes after using the Computational Thinking Skills Science E-Worksheet, according to the Anova test results, which showed a F value of 3,307 with a sig value of 0.042, indicating that the sig value < 0.05. These results show that the implementation of the E-Worksheet that has been developed has a different effect on each University. But it still has an influence on the improvement of Computational Thinking Skills. In other words, the effectiveness of media use has significantly different results from the three groups.

DISSCUSSION

Science E-Worksheets are electronic worksheets designed to facilitate interactive, independent, and technology-based science learning activities. Through *E-Worksheets*, students can access materials, explore concepts, and do learning activities digitally with an attractive and easy-to-use interface. The presence of *E-Worksheets* makes the learning process not limited to the classroom, because students can learn anytime and anywhere according to their needs (Liana & Alpindo, 2021). As a result, e-worksheets are crucial for promoting 21st-century learning, which necessitates the use of technology, critical thinking abilities, and the imagination of aspiring educators.

The goal of this project is to enhance the computational thinking abilities of Madrasah Ibtidaiyah Teacher Education project Program (PGMI) students by creating Science E-Worksheets based on Computational Thinking Skills. This E-Worksheet contains science learning activities that are packaged in the form of problem-solving activities, pattern recognition, concept abstraction, and simple algorithm design that is relevant to the context of daily life. The main purpose of this development is for PGMI pupils to comprehend science in addition to concepts theoretically, but also to be able to apply a computational mindset in designing science learning in elementary schools.

Computational thinking-based science e-worksheets are created utilizing the ADDIE approach. Needs analysis should be based on measurable learning performance gaps. In this context, e-worksheets are a potential solution because they can facilitate problem-based learning activities and concept exploration that foster a logical thinking pattern. Research results by (Djarwo et al., 2025) It also supports this, by showing that the use of digital worksheets can increase student engagement and strengthen conceptual understanding through interactive activities.

According to the needs analysis results, PGMI students require educational materials that do more than just provide information, but also provides space for reflective, analytical, and creative thinking. Computational thinking as a scientific framework requires students to be able to break down complex problems into simpler steps(Utami et al., 2024). Therefore, the e-worksheets developed need to be designed to allow students to practice identifying patterns, compiling algorithms, and evaluating results independently. In addition, it is also needed to analyze the learning environment to have a significant role in assessing how well digital learning resources are used. In the 3 PTKIN that were conducted, it is known that the learning environment of PGMI students has adequate technological infrastructure support, such as internet connections, computer devices, and e-learning platforms. However, this potential has not been optimally utilized in science learning. This condition emphasizes the importance of digital media innovation that is adaptive to the characteristics of the student learning environment. The interaction between students, lecturers, and the digital environment will affect the process of internalizing knowledge. Therefore, the design of e-worksheets needs to consider the context of the learning environment, such as the availability of technology, lecturer readiness, and academic culture on campus. Research results by (Permana et al., 2024) It shows that digital media that is contextual with the user's learning environment has a higher level of effectiveness than generic media.

On the other hand, the characteristics of PGMI students have been adapted to challenges based on real-life contexts. E-worksheets that emphasize computational thinking skills can provide meaningful learning experiences because they encourage students to think algorithmically, analyze data, and connect scientific concepts to everyday problems (Harangus & Kátai, 2020). This relates to 21st century competences, which call for students to be able to incorporate systematic thinking and digital literacy into their problem-solving techniques (Yuliansih et al., 2021). Thus, e-worksheets must be designed to facilitate thinking activities.

Following the analysis's findings, the design was completed by deciding on a learning method for creating e-worksheets based on Computational Thinking Skills (CTS) that would meet the needs of 21st-century learning and the traits of PGMI students. The CTS strategy was chosen because it focuses on the ability to think systematically, analytically, and creatively in solving problems through (Harangus & Kátai, 2020). In this stage, the researcher also designs a storyboard and determines the visual appearance of the media. This is consistent with studies (Sukardi et al., 2025) which emphasizes that a good visual structure can improve concentration, concept understanding, and student learning retention.

The next stage is development which begins with the development of interface design in Science e-worksheets based on *Computational Thinking Skills* directed to create an interactive, intuitive, and easily accessible learning experience for PGMI students. The interface design is made with the principles of visual simplicity, clear navigation, and consistency of colors and icons in mind that support the readability of the material. This idea is consistent with the results (Maharani et al., 2020) which confirms that adaptive interface design can increase user engagement in computational thinking processes, as students can focus on problem-solving without being distracted by complex visual elements. Thus, the e-worksheets interface acts as more than just a presentation medium, as well as a tool that stimulates students' logical and systematic thinking skills. In addition to developing the display, the material to be presented also needs to be developed and adjusted to the computational thinking skills component. Each piece of material is designed to lead students to analyze science phenomena through problem-based exploratory activities. This approach has shown to be beneficial in raising students' critical and reflective thinking skills, computational thinking-based learning is able to integrate

analytical skills with conceptual understanding in the field of science. Therefore, the presentation of material in e-worksheets is not only oriented towards knowledge transfer, but also on the formation of adaptive and creative scientific mindsets.

As of the now, the developed media is also assessed by experts to obtain feasibility when the media will be applied. The material expert assesses The content's relevance to education competencies and the depth of concepts according to the characteristics of PGMI students. This validation aligns with the view (Erna et al., 2021) that content quality is the foundation of effective learning media. Meanwhile, media experts evaluated aspects of interface design, navigation, interactivity, and ease of use. (Agustin et al., 2025), Attractive and easy-to-operate media display contributes to increased motivation to learn. Furthermore, learning practitioners provide feedback on the suitability of the media with real learning situations, including ease of integration into teaching methods. In line with (Bachmann et al., 2021), The involvement of practitioners ensures that the media is not only theoretically valid, but also applicable in the field. The combination of these three validations shows that the developed Computational Thinking Skills-based e-worksheet media has met the content, technical, and pedagogical feasibility aspects, so that it is ready to be implemented in the learning of PGMI students at PTKIN.

The next stage is implementation to identify the effectiveness of using E-Worksheets. The effectiveness of this product is also seen in increasing student participation and active involvement during the learning process. The activities in the e-worksheets are designed based on exploratory and contextual activities, which require students to identify patterns, make generalizations, and develop problem-solving algorithms. In addition, students show a higher interest in learning abstract concepts of science because these media combine visual elements, simulations, and engaging digital interactions. Thus, e-worksheets not only enrich the educational process, but also foster students' intrinsic motivation to think critically and productively.

After utilizing e-worksheets, students' critical thinking abilities significantly improved, according to the effectiveness test findings. Students are able to identify cause-and-effect relationships in scientific phenomena, analyze experimental data, and draw rational conclusions. This is reinforced by the opinion (Mao et al., 2021) which confirms that critical thinking skills develop optimally when students engage in evidence-based analysis and logical reasoning activities. The e-worksheets developed act as scaffolding media that guide students in the process of scientific thinking through a series of tasks and reflections based on real problems. Therefore, it can be concluded that the effectiveness of this media is not only measured from the aspect of learning outcomes, but also from improving the quality of the thinking process experienced by students.

From the affective and motivational side, students showed a positive response to the use of e-worksheets. They feel more confident in understanding science concepts and more enthusiastic in completing each learning activity. This is supported by the findings (Wardhana, 2017) which states that interactive digital learning media can increase the sense of belonging to the learning process and strengthen the motivation for independent learning. In addition, the interactivity and user-friendly interface design make students feel emotionally involved in the process of exploring the material. Thus, e-worksheets not only serve to develop cognitive abilities, but also strengthen affective aspects that support lifelong learning readiness.

Overall, the results of this study prove that *Science E-Worksheets based on Computational Thinking Skills* are effectively used in the learning of PGMI students at PTKIN. This product meets the eligibility criteria from pedagogical, technological, and psychological aspects of learning. Through the integration *of computational thinking*, students are trained to understand science concepts in depth, think in a structured way, and solve problems creatively and systematically. These results are in line with the view (Rahayu et al., 2022) that digital media innovation based on 21st century skills is able to strengthen higher *order thinking skills*. Therefore, the e-worksheets developed are not only effective in improving learning outcomes, but also a strategic means in forming a generation of prospective educators who are adaptive to the challenges of the digital era.

CONCLUSION

The study's findings demonstrate that the Computational Thinking Skills-based Science E-Worksheet media created using the ADDIE model is highly valid and appropriate for use in PGMI student learning. The evaluations of 98% of material experts, 96% of media experts, and 93% of learning practitioners all of whom fall into the extremely valid category support the media's validity. Additionally, the efficacy test using an independent sample t-test on students from three PTKINs UIN Malang, UIN Kudus, and UIN Mataram showed a sig value of 0.000 < 0.05, suggesting a substantial improvement in learning outcomes. Significant changes between student groups are also demonstrated by an ANOVA test with sig. 0.042 < 0.05, indicating that this media is both legitimate and useful for learning.This study suggests that using computational thinking-based media to teach science can be a 21st-century learning solution, particularly for PGMI students' development of critical, analytical, and problem-solving skills. In addition, this product also contributes of digital teaching materials that are relevant to the era of technology-based education, and can support the implementation of Independent Learning Independent Campus through the integration of digital media in the curriculum of Islamic religious universities. Suggestions for further research, media can be carried out in a wider scope, for example in other courses or different levels of education, to strengthen the generalization of findings. Further research is also recommended to analyze the impact of the use of this media on other variables such as learning motivation, digital literacy, and cooperation skills between students. In addition, it is necessary to develop interactive or integrated Learning Management System (LMS) features to increase the flexibility of use and accessibility in distance learning.

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