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**[Research Article]**

# DEVELOPMENT OF SCRATCH-BASED INSTRUCTIONAL MEDIA TO ENHANCE PHYSICS IDENTITY AND SCIENTIFIC LITERACY

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**ABSTRACT**

Students' understanding of physics concepts is often constrained by the abstract nature of the material and the lack of connection to real life contexts. The use of digital media that combines interactive visual with local culture element, such as the traditional procces of making geplak, can be a solution to improve students engagement and conceptual understanding. This study aims to develop Scratch-based interactive physics learning media integrated wit tradional geplak in the topic of heat and temperature, as well as to asses its feasibility and effectiveness in improving students' scientific literacy and physics identity. This research is a type of research and development (R & D) using the 4D model (Define, Design, Develop, Disseminate). The validation results showed that the developed media was categorized as highly feasible., with an average score of 90,67%. The results also indicated that the media was effective in improving scinetific literacy and in fostering students physics idnetity.

Keywords: scientifcliteracy, learning media, physics identity, scratch, heat and temperature

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## 1. INTRODUCTION

The current educational transformation in Indonesia is marked by the implementation of the *Kurikulum Merdeka* (Independent Curriculum), which provides broader opportunities for the development of students' characters and competencies. This curriculum emphasizes the significance of mastering 21st-century skills, encompassing literacy and critical thinking, to equip students for global challenges (Mulyasa, 2023). Within the context of implementing the *Kurikulum Merdeka*, physics education plays a pivotal role in facilitating more conceptual and applicative learning to cultivate these 21st-century skills among students.

However, empirical evidence indicates that the scientific literacy of senior high school students remains relatively low. For instance, the average scientific literacy score at Yayasan Umar Mas'ud Sangkapura only reached 32.56, placing it in the low category (Anshar et al., 2023). Similarly, research conducted in two public senior high schools in Singkawang City revealed that students' scientific literacy stood at only 38% in the context dimension, 40% in the knowledge dimension, and 39% in the competency dimension (Sunandar et al., 2022). Furthermore, the average scientific literacy of students in East Java achieved only 58.8% in the content aspect (Suroso et al., 2021). These findings underscore the urgent need for efforts to enhance scientific literacy through innovative instructional approaches to address this challenge.

The low level of students' scientific literacy is intertwined with various factors, including a minimal interest in reading, limited utilization of instructional media in the classroom, and a lack of teacher guidance in facilitating the learning process (Anshar et al., 2023). Students' limitations in expressing their thoughts in writing and their weak reasoning abilities further contribute to poor scientific literacy outcomes (Suroso et al., 2021). Additionally, the level of student comprehension regarding abstract physics concepts remains inadequate. Research conducted at SMA Negeri 04 Bombana demonstrated that students' average misconception rate regarding temperature and heat reached 66.5%, indicating that students still struggle to connect physics concepts with everyday phenomena (Asmin & Rosdianti, 2021).

These various challenges underscore the need to develop instructional media that are not only visually appealing but also contextually relevant to the students' local culture. The *Kurikulum Merdeka* encourages teachers to design active and contextual learning experiences so that students can develop learning, literacy, and life skills (González-Pérez & Ramírez-Montoya, 2022). The development of Scratch-based instructional media integrated with the traditional food *geplak* represents an innovation that bridges physics concepts with real-world phenomena familiar to students. By linking the concepts of temperature and heat to the *geplak* making process, students are expected to achieve a better understanding of the material through a contextual learning experience.

A primary challenge in physics education pertains to the abstract concepts being taught, which are often difficult for students to visualize. In this regard, technology-based instructional media such as Scratch can serve as a highly relevant solution. Scratch enables teachers and students to create visual and interactive simulations to elucidate complex physics phenomena (Bouchée et al., 2022). This platform also aligns with 21st-century demands by promoting the integration of digital technology skills within the teaching and learning process. The utilization of Scratch presents an opportunity to create a physics learning experience that is more engaging, appealing, and comprehensible for students.

Beyond reinforcing cognitive aspects, physics education must also address students' affective domains and their physics identity. Physics identity is a concept that refers to students' perceptions, interests, and self-recognition in relation to physics, including the extent to which they feel capable and engaged in the subject

(Hazari et al., 2010). This identity can be strengthened through meaningful and relevant learning experiences, including the use of instructional media that connect scientific content with cultural contexts and real life. Therefore, the development of contextual instructional media integrated with local culture is crucial to support the formation of a robust physics identity.

Scientific literacy, as a crucial 21st-century competency, must also be incorporated into instructional design. This competency encompasses the comprehension of scientific concepts, the application of science in everyday decision-making, and the evaluation of evidence-based information (Anshar et al., 2023). Studies conducted across various regions indicate that students' scientific literacy remains far below expected standards. Consequently, innovative and contextual instructional strategies are required to improve these outcomes (Suroso et al., 2021). Integrating technology with local wisdom through the development of Scratch-based media centered on the *geplak* making process emerges as a potential strategy to address this need.

Accordingly, this study aims to develop interactive, Scratch-based physics instructional media integrated with the traditional food *geplak*, as well as to investigate its feasibility and effectiveness in enhancing the physics identity and scientific literacy of senior high school students.

## 2. METHOD

This study utilizes a Research and Development (R&D) approach employing the 4D development model, which consists of four stages as illustrated in Figure 1.


**Figure 1.** Stages of R&D using the 4D model.

Each stage in the 4D model is designed to ensure that the development process of the Scratch-based media, integrated with the traditional food *geplak*, proceeds systematically, ensuring that the final product aligns with the requirements of physics education at the senior high school level.

The Define stage is conducted to identify and analyze instructional needs. This analysis encompasses an examination of teaching materials, student characteristics, and the obstacles encountered during the physics learning process in the classroom. A preliminary study was carried out through direct observation, interviews with physics teachers, and curriculum analysis. The outcomes of this stage serve as the foundation for designing relevant and contextual instructional media.

The Design stage focuses on the initial drafting of the interactive Scratch-based instructional media, which is linked to a local cultural phenomenon—specifically, the process of making the traditional food geplak. This stage is executed by creating a concept map of the material, examining the geplak making process, compiling the content for the media, designing the user interface, and programming within the Scratch platform.

The concept map is developed based on the learning outcomes for the topics of temperature and heat, as well as their relationship to the geplak making process.


**Figure 2.** Concept Map of the Material.

The material review was based on observations of the *geplak* making process, which involves the concepts of temperature and heat. The

highlighted phenomena relate to temperature changes, heat transfer, and phase changes. The stages of making *geplak* are illustrated in Figure 3.

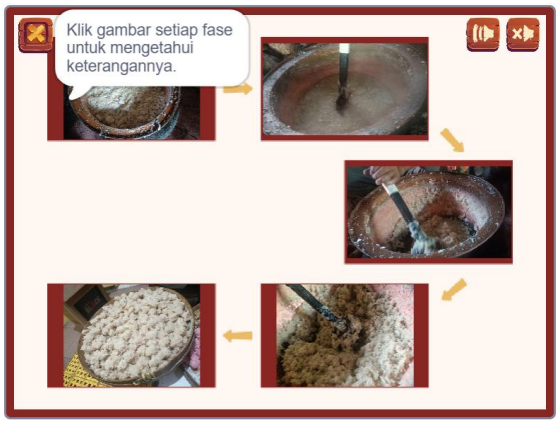


**Figure 3.** Stages of Making Geplak.

The materials were systematically arranged based on the developed concept map. Subsequently, the materials were integrated into the media interface design. This stage involved designing the media interface, the navigation flow, and the content for the temperature and heat material, which were incorporated into the media using the Canva platform.

**Figure 4.** Media Interface Design.

The design process was conducted by taking into account elements of interactivity, ease of use for the students, and the connection between physics concepts and everyday phenomena.

The Develop stage constitutes the process of developing and validating the designed media product. The media was developed by integrating the design outcomes using the Scratch programming language.


**Figure 5.** Media Programming in Scratch.

The developed instructional media comprises four main menus: information, exploration, elaboration, and evaluation. Each menu displays a distinct section corresponding to its respective function. The information menu contains user instructions, developer information, and the concept map. The exploration menu encompasses the stages of making *geplak* and their relevance to the taught material. In this section, students are also directed to engage in learning activities, either individually or in groups, guided by a Liveworksheet-based Student Worksheet (LKPD). The elaboration menu contains the Student Worksheet and material descriptions. Meanwhile, the evaluation section provides a QR code that directs students to complete the post-test. Several views of the media interface are presented in Figure 6.


**Figure 6.** Exploration Interface of the Scratch Media.

The developed media was subsequently validated by media experts and educational practitioners to assess the feasibility of the design and interface, content, language, as well as accessibility and ease of use. Based on the experts' feedback, revisions were made to the media prior to conducting trials with the students. The trials were executed in two stages, namely a limited trial and a field trial. The limited trial was conducted at SMA GAMA Yogyakarta, aiming to ascertain the students' initial responses to the media. The analysis of the validation and the students' response results to the media utilized the Ideal Standard (*Standar Baku ideal* or SBi) using the following equation:

$$\bar{X} = \frac{\Sigma X}{N}$$

Where:
$\bar{X}$: Mean score
$\Sigma X$: Total item score for each assessment aspect
$N$: Number of respondents

**Table 1.** Assessment Categories.

| Interval | Category |
|---|---|
| $\bar{X} > M_i + 1{,}8\ SBi$ | Highly Feasible |
| $M_i + 0{,}6\ SBi < \bar{X} \leq M_i + 1{,}8\ SBi$ | Feasible |
| $M_i - 0{,}6\ SBi < \bar{X} \leq M_i + 0{,}6\ SBi$ | Fairly Feasible |
| $M_i - 1{,}8\ SBi < \bar{X} \leq M_i - 0{,}6\ SBi$ | Less Feasible |
| $\bar{X} \leq M_i - 1{,}8\ SBi$ | Not Feasible |

Following revisions based on the limited trial results, a field trial was conducted at SMAN 2 Yogyakarta. This trial involved a larger number of students and was utilized to test the overall effectiveness of the media within an actual instructional context. The field trial employed a quasi-experimental design involving three classes, namely two experimental classes and one control class. The research subjects consisted of eleventh-grade students from these three classes. Experimental Class 1 implemented physics learning utilizing the Scratch-based instructional media integrated with the traditional food *geplak* through a contextual approach. Experimental Class 2 implemented learning utilizing a contextual approach without the Scratch-based media. Meanwhile, the Control Class implemented conventional, teacher-centered physics learning. Each class was administered a pretest and posttest, alongside a physics identity questionnaire before and after the learning process.

This research was conducted at SMAN 2 Yogyakarta, involving eleventh-grade students as the research subjects. The data collection techniques employed included observation, interviews, pretests and posttests, and questionnaires. All instruments underwent validation and reliability testing processes to ensure data accuracy and consistency. Data analysis was conducted both qualitatively and quantitatively. Qualitative data were utilized to assess the feasibility of and responses to the media. Conversely, quantitative data were used to measure the improvement in scientific literacy and physics identity before and after the utilization of the instructional media. The analysis employed normalized gain (N-gain) as follows:

$$g = \frac{\bar{X}_2 - \bar{X}_1}{\bar{X} - \bar{X}_1}$$

Where:
$\bar{X}_1$: Average pretest score
$\bar{X}_2$: Average posttest scor
$\bar{X}$: Maximum possible score

**Table 2.** N-gain Score Categories.

| Interval | Category |
|---|---|
| $g > 0{,}7$ | High |
| $0{,}3 \leq g \leq 0{,}3$ | Medium |
| $g < 0{,}3$ | Low |

The Wilcoxon Signed-Rank Test was conducted utilizing SPSS software. If the significance value < 0,05 the null hypothesis $H_0$ is rejected conversely, if the significance value is > 0,05 $H_0$ is retained.

The Disseminate stage constitutes the widespread distribution of the developed instructional media. This dissemination was executed by providing physics teachers and students with access to the media. Furthermore, the media was also published on the Scratch platform to facilitate broader utilization.

## 3. RESULT AND DISCUSSION

The Scratch-based physics instructional media developed in this study has undergone processes of validation, limited trials, and field trials to assess its feasibility and effectiveness in enhancing students' scientific literacy and physics identity.

### 3.1 Media Validation Results

The developed instructional media was validated by media experts and a physics teacher acting as an educational practitioner. The assessment was conducted on the aspects of media design and interface, content, language, as well as accessibility and ease of use. Based on the validation results, the overall average score reached 91.3%, which is categorized as highly feasible. The average score for each aspect is presented in Figure 7.

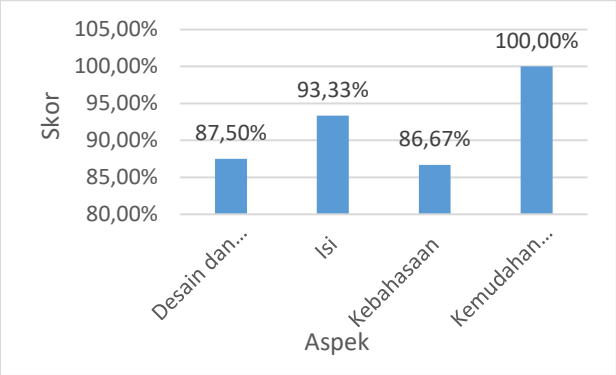


**Figure 7.** Graph of the Instructional Media Feasibility Test Results.

These validation results served as the foundation for proceeding to the limited trial stage.

### 3.1

### 3.2 Limited Trial Results

The limited trial was conducted at SMA GAMA Yogyakarta, involving a small group of students. This aimed to determine the students' initial responses to the developed media. Data were collected utilizing a student response questionnaire. The assessment encompassed the aspects of media design and interface, accessibility and ease of use, interactivity in learning, as well as learning motivation and interest. The results of the students' responses to the media are presented in Figure 8.

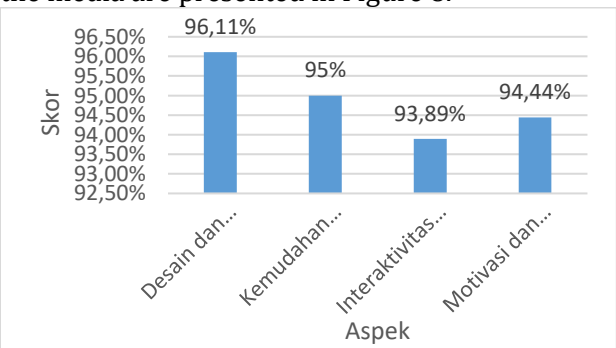


**Figure 8.** Graph of Student Responses to the Media.

The majority of students provided positive responses to the developed media. The students evaluated the media as engaging, interactive, and capable of assisting them in comprehending physics material that is generally considered

difficult. The suggestions provided pertained to difficulties encountered when scanning the QR code and the duration of the chat bubbles, which appeared too quickly. These suggestions were well-received and utilized as a basis for refining the developed media prior to further testing.

### 3.3 Field Trial Results

The field trial was conducted at SMAN 2 Yogyakarta with eleventh-grade students, comprising three classes: two experimental classes and one control class. All classes underwent pretests and posttests utilizing the same instruments for both scientific literacy and physics identity.

The data analysis results revealed that Experimental Class 1 experienced the most significant improvement compared to the other two classes. Regarding the scientific literacy aspect, the average pretest and posttest scores of students in Experimental Class 1 demonstrated an increase with an N-gain value of 0.87, which falls into the high category. This improvement indicates the success of the instructional media in assisting students to comprehend the concepts of temperature and heat through interactive and contextual visualization. Meanwhile, Experimental Class 2 and the Control Class exhibited moderate improvements with N-gain values of 0.60 and 0.50, respectively. These results indicate that contextual learning without Scratch-based media can improve scientific literacy, but it is not as effective as when supported by interactive digital learning.

Regarding the physics identity aspect, the data analysis results showed that Experimental Class 1 also experienced a higher increase compared to the other classes. The average physics identity score of the students before and after learning in this class yielded an N-gain of 0.57, categorizing it as medium. Meanwhile, Experimental Class 2 obtained an N-gain of 0.31 (medium category), and the Control Class obtained an N-gain of 0.15 (low category). These findings are reinforced by the results of the Wilcoxon Signed-Rank Test, which demonstrated that the increase in physics identity scores was statistically significant with a p-value $< 0.05$. These results indicate that the utilization of Scratch-based instructional media is demonstrably capable of exerting a significant influence on the development of students' physics identity.

### 3.4 Discussion

The feasibility of the Scratch-based physics instructional media, which obtained high validation scores, indicates that the media is viable for effectively supporting the learning process. Assessments of the design, content, language, and accessibility aspects which were classified as highly feasible prove that this media is not only visually appealing but also easily accessible to students. These findings align with research by Damayanti & Perdana (2024), which states that utilizing Scratch as an instructional medium can facilitate the comprehension of abstract physics concepts through interactive learning, thereby contributing to the enhancement of students' critical thinking and problem-solving skills.

The positive student responses during the limited trial stage reinforce the feasibility of the developed media. Maharani & Perdana (2024) also emphasized the importance of student evaluation and feedback in the development of Scratch-based instructional media to ensure it remains attentive to student needs. This media was deemed interactive and capable of facilitating comprehension, particularly concerning the topics of temperature and heat. Suggestions for improvement, such as difficulties in scanning the QR code and the duration of the chat bubbles, served as guidelines during the media refinement process.

The media's effectiveness is evidenced by the improvement in students' scientific literacy. The N-gain value of 0.87 in Experimental Class 1 was higher than those in Experimental Class 2 and the Control Class, indicating a significant impact from the utilization of this media. These results support the findings of Damayanti & Perdana (2024), who revealed that Scratch-based instructional media

can significantly improve physics learning outcomes through interactive and contextual visualization. As emphasized by Rahmawati et al. (2019), interactive digital media allows students to understand concepts deeply while simultaneously increasing active participation in the learning process.

The developed Scratch-based media also contributed to strengthening the students' physics identity. A significant increase occurred in Experimental Class 1, indicating that the use of interactive media such as Scratch not only reinforces cognitive aspects but also shapes students' identities as physics learners. This is crucial because a strong physics identity is closely correlated with learning motivation and sustained interest in the field of physics (Hyater-Adams et al., 2018). Media that combines interactive and contextual elements encourages students to feel more engaged, confident, and motivated throughout the learning process.

Consequently, the results of this study corroborate that the Scratch-based instructional media integrated with the traditional food *geplak* is both feasible and effective in enhancing the physics identity and scientific literacy of senior high school students.

## 4. CONCLUSION

Based on the results of the research conducted, it can be concluded that the interactive Scratch-based physics instructional media integrated with the traditional food *geplak* has been successfully developed. This media possesses an appealing interface, incorporates interactive and contextual features, and is highly accessible to students. Expert validation indicates that this media is highly feasible for implementation within the instructional process. Furthermore, the trial results demonstrate that this media is proven effective in enhancing scientific literacy and is capable of fostering the students' physics identity.

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