



## How Does the STEM-PjBL e-Book Impact Students' Creative Thinking and Digital Literacy Skills?

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**Abstract:** Current learning developments are adapted to society's needs, which have developed and entered the 21<sup>st</sup> century. Creative thinking abilities and digital literacy are 21<sup>st</sup> century competencies that students need to develop. This study investigates the impact of an e-book STEM-PjBL on seventh-grade students' creative thinking skills and digital literacy. The research employs a quantitative approach using a one-group pretest-posttest design involving a sample of 32 students selected through random sampling at one of Sleman's public junior high schools. The study utilizes a creative thinking test and a digital literacy questionnaire to assess students' skills before and after the intervention. This research highlights the importance of innovative teaching materials in enhancing students' learning experiences and outcomes. The findings reveal that the STEM-PjBL e-book enhances students' creative thinking abilities, with gain scores categorized as moderate across the aspects of Fluency (0.45), flexibility (0.38), and novelty (0.60). Additionally, students' digital literacy is positively impacted, with the aspect of using skills rated as "very good" (85.1%), while collaboration skills (81.3%) and communication skills (83.5%) are categorized as "good." The results indicate that integrating technology through STEM-PjBL e-books fosters creative thinking and improves students' digital literacy, thereby addressing the educational needs of the 21<sup>st</sup> century.

**Keywords:** creative thinking; digital literacy; e-Book; PjBL; STEM

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## INTRODUCTION

The evolution of education in the 21st century is increasingly aligned with the dynamic needs of contemporary society. As we transition into this new era, educational indicators must be adapted to ensure that learning processes are congruent with the competencies required for success in the 21st century. The Partnership for 21st Century Skills (P21), a U.S.-based initiative, identifies essential competencies for this era as "The 4Cs": creativity, critical thinking, collaboration, and communication (Rosana, 2020). Among these, creative thinking skills are particularly vital, empowering students to engage in critical and innovative thought processes (Apriliansa et al., 2018). However, current assessments reveal a concerning trend: students' creative skills are notably underdeveloped. For instance, Indonesia's performance in the Programme for International Student Assessment (PISA) test highlights this issue, with the country scoring a mere 389 in science, ranking 70th out of 78 participating nations. The PISA framework encompasses four problem content areas: Space and Shape, Uncertainty, Quantity, and Change and Relation (Umami et al., 2021), necessitating robust creative thinking skills for effective problem-solving. Unfortunately, Indonesian students often struggle with non-routine problems, leading to responses that lack creativity (Handayani et al., 2018). Almuharomah et al. (2019) further corroborate this finding, indicating that students exhibit low creative thinking skills, primarily due to a deficiency in learning media that integrates technology to foster creativity.

In the context of 21st-century education, the integration of technology into teaching materials is paramount. The Assessment and Teaching of 21<sup>st</sup> Century Skills (AT21CS) categorizes essential skills into four groups: ways of thinking, ways of working, tools for working, and skills for living (Griffin et al., 2012). The latter category encompasses information literacy, proficiency in new information communication technologies, and the ability to navigate and collaborate within digital social networks (Väisänen & Hirsto, 2020). Consequently, managing information through digital devices is critical to digital literacy. Incorporating information technology in education is essential for transforming traditional teacher-centered paradigms into more engaging student-centered learning environments (Fitriyani & Nugroho, 2022). Integrating information technology into learning is considered important because using information technology in education can shift the learning paradigm from teacher-centered to student-centered. Using technology in learning models can create active and collaborative learning environments and enhance students' motivation, skills, and thinking structures (Halimatul Mu et al., 2019). One effective method for integrating technology into the learning process is using e-books as educational resources (Us et al., 2019). E-books, particularly in environmental education, have shown promise in enhancing

digital literacy among teachers and students due to their interactive features, such as videos, games, and pop-up images (Qumillaila et al., 2022). The content presented through e-books is more diverse, including images, animations, graphics, sounds, and even videos, making e-books more interactive and attractive for students than printed learning resources (Annisyah, 2021). E-books in science education are considered effective in improving student learning outcomes and science literacy skills (Latip & Faisal, 2021). E-books can also enhance students' critical thinking skills (Mastuti et al., 2023) and increase students' motivation to learn (Musdalifa et al., 2021). Adawiyah et al. (2019) indicate that interactive e-books on rotational dynamics can significantly improve students' creative thinking skills, as these resources include various simulations, animations, and instructional videos.

Moreover, technology-integrated teaching materials can be designed based on specific learning models and approaches that cater to students' needs. One such approach is the STEM (Science, Technology, Engineering, and Mathematics) framework, which encourages students to analyze data from multiple perspectives, evaluate information, and devise innovative solutions (Nurhikmayati, 2019). The STEM approach fosters critical, responsive, collaborative, and creative exploration and expression of ideas (Sumarni & Kadarwati, 2020). A complementary learning model that optimizes the STEM approach is Project-Based Learning (PjBL), which emphasizes student-centered experiences and meaningful engagement (Capraro et al., 2013). Project-based learning (PjBL) is a learning model that provides students with meaningful experiences through the products generated in the PjBL process (Afriana et al., 2016). PjBL aims to guide students in a collaborative project that integrates various subjects, provides opportunities to explore content meaningfully, and engages students in collaboration (Tibahary & Muliana, 2018). This aligns with Parno et al. (2020), who state that PjBL is a model that uses problems as a starting point for gathering and integrating new knowledge based on students' experiences. PjBL is designed to address complex problems that require students to conduct investigations and understand them.

A pertinent topic within junior high school science education is temperature and heat, which are intrinsically linked to everyday life. However, students frequently encounter difficulties in grasping these concepts. These challenges often arise from discrepancies between scientific definitions, everyday understandings of temperature and heat, and different complexities in comprehending these phenomena (Foroushani, 2019). Teaching materials, specifically e-books focused on temperature and heat, are proposed to address these issues, utilizing the STEM approach and the project-based learning model. This study investigates the impact of STEM-PjBL e-books on students, particularly in enhancing their creative thinking skills and digital literacy. By framing the problem within the context of existing literature, this research seeks to clarify the barriers and knowledge gaps that hinder the development of creative thinking and digital literacy among students, ultimately addressing the practical needs of contemporary education.

## METHODS

This quantitative study uses an experimental method with a one-group pretest-posttest research design (Creswell & Creswell, 2017). The population comprises seventh-grade students at a public junior high school in Sleman in the 2023/2024 academic year. The sampling technique used is random sampling, where each student is given an equal opportunity to be selected as a research sample (Sumargo, 2020). The population includes four classes with 128 students, from which the sample was randomly selected. Based on the random selection, the sample chosen is class VII C, with 32 students. The curriculum used at this school is the 'Merdeka Belajar' curriculum. Currently, the models frequently employed in learning are cooperative learning, inquiry learning, and discovery learning. The methods commonly used include discussions, question-and-answer sessions, and lectures. A common issue teachers face regarding students is that they tend to be passive; therefore, it is necessary to implement learning that involves active student participation. Based on the results of the Mid-Semester Assessment and the End-of-Semester Assessment for the science subject, some students have low, medium, and high cognitive abilities. The research instruments used in this study are a creative thinking test and a digital literacy questionnaire. The creative thinking ability test is an essay with five questions on temperature and heat. Students' creative thinking abilities were analyzed using a normalized gain score. The gain score calculation follows the steps from Hake's (1999) formula to assess student responses on a 100-point scale. The criteria for improvement in students' creative thinking skills were determined based on the criteria in Table 1.

**Table 1.** n-Gain Limits and Categories

| Limit              | Category |
|--------------------|----------|
| $g \geq 0.7$       | High     |
| $0.3 \leq g < 0.7$ | Medium   |
| $g < 0.3$          | Low      |

(Hake, 1999)

A digital literacy questionnaire containing 10 statements examined students' digital literacy. The digital literacy questionnaire is based on three aspects: using skills, collaboration skills, and communication. Students' digital literacy questionnaire data was analyzed by assigning scores to the questionnaire based on the Likert scale. The Likert scale and its criteria are explained in Table 2.

**Table 2.** Likert Scale Scores and Criteria

| Score | Criteria          |
|-------|-------------------|
| 4     | Strongly Agree    |
| 3     | Agree             |
| 2     | Disagree          |
| 1     | Strongly Disagree |

The questionnaire scores were then converted into percentages by comparing the obtained scores to the highest score on the Likert scale and multiplying by 100%. These percentage results were then interpreted into assessment categories to determine students' digital literacy levels. The criteria for interpreting the questionnaire can be seen in Table 3.

**Table 3.** Questionnaire Interpretation Criteria

| Score Range (%) | Category  |
|-----------------|-----------|
| 85.01 – 100.00% | Very Good |
| 70.01 – 85.00%  | Good      |
| 50.01 – 70.00%  | Fair      |
| 01.00 – 50.00%  | Poor      |

(Fatmawati, 2016).

## RESULT AND DISCUSSION

This study aims to determine the impact of using a STEM-based e-book integrated with the Project-Based Learning model. The STEM-PjBL e-book contains material on temperature and heat. The learning objectives of this e-book are for students to accurately distinguish between the concepts of temperature and heat through observation and discussion activities. Additionally, students should be able to measure temperature changes caused by heat transfer by accurately completing a project to create a simple thermometer. The e-book in this study follows the steps of Project-Based Learning, which include starting with the essential question, designing a plan for the project, creating a schedule, monitoring the project activities and progress, assessing the outcome, and evaluating the experience (Widiasworo, 2020). Each stage of PjBL in the e-book is integrated with the STEM (Science, Technology, Engineering, Mathematics) approach to enhance students' creative thinking skills and digital literacy. According to Wessels (2014), students' creative thinking abilities consist of Fluency, Flexibility, and Novelty. Fluency is the ability to generate various solutions to a problem. Flexibility involves applying different approaches to solve a problem. Novelty refers to the originality in developing solutions to a problem (Ismayani, 2016). In this study, students were given a pretest before and a posttest after learning with the e-book. The pretest and posttest contained questions on temperature and heat from the e-book, designed to align with the three aspects of creative thinking. The pretest and posttest results were then analyzed to determine the gain score in students' creative thinking abilities. Based on data analysis, the gain scores for students' creative thinking skills are presented in Table 4.

**Table 4.** Analysis Results of Students' Creative Thinking Skill Gain Scores

| Aspect      | Gain Score | Category |
|-------------|------------|----------|
| Fluency     | 0.45       | Moderate |
| Flexibility | 0.38       | Moderate |
| Novelty     | 0.60       | Moderate |
| Average     | 0.47       | Moderate |

Table 4 shows that students' creative thinking skills improved across all indicators after using the STEM-PjBL e-book, with gains categorized as moderate. This finding aligns with (Sumarni & Kadarwati, 2020), who reported that implementing a STEM-based project-based learning approach can effectively enhance students' creative thinking skills to a good level. In Fluency, the gain score for students' creative thinking skills falls within the moderate category. The Fluency aspect was assessed through questions related to temperature and heat. One question presented an image comparing temperatures in several glasses containing liquids at different

temperatures, where students were asked to choose and justify their selection. Students' responses confidently choose and provide varied explanations based on their understanding of temperature and heat concepts. This fluency aspect can be improved through the use of the STEM-PjBL e-book at the "start with the essential question" stage. In this stage, students are presented with images depicting problems related to temperature and heat, encouraging them to offer various ideas or answers to the posed questions. This aligns with [Candra et al. \(2019\)](#), who noted that the initial stage of PjBL, involving fundamental questions, can enhance students' creative thinking skills in the Fluency aspect. The next creative thinking skill assessed is flexibility, which achieved a gain score in the moderate category. One question presented a scenario about temperature and heat in everyday life, requiring students to explain the reasoning behind such occurrences. Students can flexibly analyze and express their thoughts or ideas, drawing on their creative insights and real-life experiences. This Flexibility aspect can be enhanced using the STEM-PjBL e-book during the assessment stage. In this stage, students evaluate and reflect on the projects or products they have created. Flexibility is fostered as students present their completed projects and respond effectively to questions from classmates and teachers. This aligns with [Rohmah \(2021\)](#), who shows that the evaluation phase of PjBL-STEAM-based learning can facilitate improvements in students' creative thinking skills, particularly in Fluency and Flexibility.

The next aspect of creative thinking assessed is novelty, which also achieved a moderate gain score. In one question, students were presented with a news article on temperature and heat issues in the environment and asked to propose solutions to address the problem. Students can present ideas for solving a problem related to temperature and heat. The novelty aspect can be improved by using the STEM-PjBL e-book during the stages of designing project activities, creating a schedule, and monitoring project progress. During these stages, students are guided to design a product or solution to a problem, develop a schedule for product creation, and monitor the progress of their product development. These phases train students to think creatively by combining various tools and materials, planning each process step, and evaluating whether the product meets the intended design and purpose. This aligns with [Alhazizah et al. \(2019\)](#), who found that Project-Based Learning can enhance students' creative thinking skills in the Novelty aspect. The integration of STEM-PjBL significantly enhances students' creative thinking skills. Research indicates that this approach fosters creativity through hands-on, interdisciplinary projects, allowing students to engage deeply and develop innovative problem-solving abilities ([Fitriyah & Ramadani, 2021](#)). Students' digital literacy was assessed across three aspects: Using Skills, Collaboration Skills, and Communication ([Belshaw, 2012](#); [Hague & Payton, 2011](#); [Monggilo, 2020](#)). *Using Skills* refers to using digital devices to access information from reliable sources. *Collaboration Skills* involve using digital devices to work and interact actively with others to produce outcomes. *Communication* is the skill of conveying processed information and disseminating created products. The analyzed results of the digital literacy questionnaire are detailed in Table 5.

**Table 5.** Analysis of Student Digital Literacy Data

| Digital Literacy Aspect | Mean | Percentage (%) | Category  |
|-------------------------|------|----------------|-----------|
| Using Skills            | 3.40 | 85.1           | Very Good |
| Collaboration Skills    | 3.25 | 81.3           | Good      |
| Communication           | 3.34 | 83.5           | Good      |

Based on the analysis of students' digital literacy data, the Using Skills aspect falls into the "Very Good" category, while Collaboration Skills and Communication are in the "Good" category. During the science lesson on temperature and heat using the STEM-PjBL e-book, digital literacy in the Using Skills aspect is cultivated as students are guided to use the e-book as learning material. With the e-book, students can search for information on temperature and heat topics, both from the content provided and through embedded reading links and videos ([Mustofa & Budiwati, 2019](#)). This digital format enables students to access materials, worksheets, and questions anytime and anywhere via digital devices like smartphones and laptops. The STEM-PjBL e-book also supports enhancing digital literacy in collaboration skills and communication. It allows students to work on projects that address real-world problems using their digital devices. This is supported by [Faridah et al. \(2022\)](#), who state that the use of the PjBL (project-based learning) model influences students' ability to communicate the results of their constructions related to their experiences with numeracy and digital literacy materials, becoming more active in sharing their ideas, and being able to represent mathematical situations in the form of graphs, tables, diagrams, or equations.

Applications like Google and YouTube provide additional resources for exploring the science content. Furthermore, collaborative tools like WhatsApp, Google Docs, and Google Classroom enable students to communicate and work together on projects related to temperature and heat. Social media platforms like WhatsApp, Facebook, Instagram, and TikTok allow students to upload and share their project outcomes, further integrating digital literacy skills into their learning process ([Nurchaili, 2016](#)). Integrated STEM-PjBL learning can

serve as an alternative learning method that allows students to learn independently at home by utilizing the digital technology they possess. Using mobile learning in e-books is expected to enhance digital literacy and promote independent learning patterns among students (Nurcahyo & Setyowati, 2021). The findings indicate that students demonstrated moderate improvements across all aspects of creative thinking: Fluency, flexibility, and novelty after engaging with the e-book. Additionally, the digital literacy assessment revealed that students excelled in using digital tools effectively while showing good collaboration skills and using digital tools effectively. The integration of STEM-PjBL fosters a deeper understanding of scientific concepts such as temperature and heat and equips students with essential skills for the digital age. As education continues to evolve, incorporating innovative resources like STEM-PjBL e-books can prepare students to tackle actual challenges and thrive in an increasingly complex and interconnected world. This approach enhances academic performance and nurtures the creativity and digital competencies necessary for future success.

## CONCLUSION

Based on the research results and discussion, it can be concluded that the STEM-based e-book with the Project-Based Learning (STEM-PjBL) model, used by seventh-grade students in class VII C at SMP N 5 Depok, Sleman Regency, successfully improved creative thinking skills. The improvement in creative thinking skills in Fluency reached 0.45, which is categorized as moderate. In flexibility, it reached 0.38, also moderate, and in novelty, it reached 0.60, moderate as well. Students' digital literacy in the aspect of Using skills was in the very good category, with a percentage of 85.1%. Digital literacy in Collaboration skills had a percentage of 81.3%, and communication had a percentage of 83.5%, both categorized as good.

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