JELS Journal of Education and Learning Sciences
E-ISSN : 2808-3695

Vol 06 No 01 March 2026
http://jurnal.gerakanedukasi.com/index.php/gerasi
https://doi.org/10.56404/jels.v6i1.246

STEM-PjBL Learning through Seblak Rafael Project to Increase Students' Science Literacy on the Topic of Heat and Temperature

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ABSTRACT : The Program for International Student Assessment (PISA) has released the results of the 2022 ranking, where the average score of Indonesian students' scientific literacy skills has decreased. The results of a preliminary study at SMAN 5 Banjarbaru showed that one of the factors in the decline in scientific literacy was the lack of student participation in physics learning because it was considered difficult by students. To overcome this problem, project-based learning (PjBL) was implemented with STEM integration through viral food on social media called Seblak Rafael. The purpose of this study was to describe the implementation of STEM-PjBL learning through the Seblak Rafael project and the increase in students' scientific literacy after participating in the learning. This study used a mixed method with an Embedded Design. The research subjects consisted of 39 eleventh grade students. Data on the implementation of STEM-PjBL learning through the Seblak Rafael project were obtained through observation which was then subjected to descriptive analysis. Scientific literacy data were obtained through tests with reasoned multiple-choice questions which were then analyzed for improvement using N-gain. The results of the study showed that the implementation of STEM-PjBL learning through the Seblak Rafael project obtained a percentage of 87% in the very good category with the stages of starting with the essential question, designing a plan for the project, creating a schedule, monitoring the student and the progress of the project, assessing the outcome, evaluating the experience. The increase in students' scientific literacy through this learning obtained an N-Gain value of 0.53 which is included in the moderate criteria.

Key words: STEM-PjBL; Seblak Rafael; Science Literacy; Heat and Temperature

INTRODUCTION

On 5 December 2023, the Organisation for Economic Co-operation and Development (OECD) released the findings of the International Student Assessment Program (PISA), which was conducted in 81 countries and involved 690,000 students with an average age of 15 years. The assessment focused on evaluating students' mathematical, scientific, and reading abilities. Indonesia is one of the countries participating in the programme. The PISA results indicate that Indonesia exhibited an increase in ranking in 2022 relative to the 2018 PISA results. Despite this increase in

ranking in 2022, Indonesia demonstrated a decline in scores for learning outcomes in scientific literacy, mathematics and reading internationally (OECD, 2019; OECD, 2023).

The Minister of Education, Nadiem Anwar Makarim, stated that, despite the decline in Indonesia's PISA scores, Nevertheless, Indonesia's ranking appears to have improved in comparison to the previous year. This improvement in ranking demonstrates the efficacy of the Indonesian education system in addressing the learning loss caused by the pandemic. This can be attributed to the implementation of an emergency curriculum that simplifies the material. This curriculum represents the primary guiding principle in the development of the Independent Curriculum (Ministry of Education and Culture, 2023). The most significant alteration to the Merdeka Curriculum is the incorporation of a project-based learning approach. In this curriculum, students are not only instructed in theory, but are also directly engaged in project activities that facilitate a deeper comprehension of the subject matter (Oktaviani & Ramayanti, 2023). One learning model that is anticipated to equip students with requisite skills is through project-based learning (PjBL) and STEM. PjBL is a student-centred learning approach that enables students to develop creative ideas and solve problems pertinent to their social lives. STEM learning (Science, Technology, Engineering, and Math) encourages students to engage in active learning (R. Amelia & Santoso, 2021).

The integration of these skills is important because science requires mathematics for data processing, while technology and engineering are used to apply scientific concepts in real situations. The integration of these skills ensures that students not only understand the concepts, but can also apply them in the real world (Pratiwi & Rachmadiarti, 2021). Therefore, it is necessary to combine STEM skills in project-based learning (PjBL). This is what is known as STEM-PjBL learning (Amri et al., 2020). Learning that integrates STEM-PjBL into the context of real world problems can make learning more relevant for students and teachers. This can ultimately lead to motivation to learn, increase interest and persistence (Suryani et al., 2023). However, most existing studies primarily focus on cognitive outcomes or general engagement, with limited attention to contextual learning approaches that are closely aligned with students' daily experiences and digital culture.

Based on a preliminary study at SMAN 5 Banjarbaru school. Researchers conducted interviews with physics subject teachers and distributed questionnaires filled out by class XII students. The results of interviews with physics teachers at SMAN 5 Banjarbaru explained that an obstacle that arises in learning physics is the lack of student activity, which has an impact on their understanding and learning outcomes. This means it is related to the skills of understanding and applying scientific concepts,

or what is called scientific literacy. Scientific literacy greatly influences students' learning outcomes, the higher the level of scientific literacy, the better the learning outcomes they can achieve (Roy et al., 2025). Scientific literacy involves understanding scientific concepts, the ability to analyze and evaluate information, and making decisions based on that information. Literacy, means to be literate or able to see, is the basis for the concept scientific literacy introduced by Paul DeHart Hurd in the 1950s. Hurd explained Scientific literacy as an understanding of science and its ability to be applied in society (Wasis et al., 2020). The PISA definition of scientific literacy is a person's ability to engage in scientific issues and scientific ideas as a reflective citizen. Individuals who have scientific literacy are able to participate in reasoned scientific conversations, understand and explain scientific phenomena, evaluate and design scientific investigations, and interpret data and evidence scientifically. This reflects a person's readiness to engage in science and technology discourse with good competence (OECD, 2023).

The material that will be examined in this research is temperature and heat, because students are known to often misunderstand the difference between temperature and heat (Angelita et al., 2023). This is also proven through the questionnaire responded to by 41 Class XII students at SMAN 5 Banjarbaru provides an in-depth picture of students' perceptions of physics lessons. The survey results showed that as many as 82.9% of students considered physics lessons difficult, with 58.5% of students finding the temperature and heat material easy to understand. However, when students are asked to explain the concepts of temperature and heat in the context of everyday life, 75.6% of students were not able to explain the difference between temperature and heat in everyday life. From these data, it can be concluded that the majority of students still experience difficulties in this material. To overcome this problem, a learning approach that is integrated with everyday life is needed. In this case, the researcher chose to relate the material of temperature and heat to the process of making food, by considering how students' attachment to social media resulted in the researcher applying this in the process of making food that is currently viral, namely, Rafael's seblak. With things going viral, interest in learning can increase because what is displayed on social media has a significant influence on their perceptions and interests (Umaroh, 2023). Social media has a big role in shaping public opinion, including in the educational context. Therefore, utilizing viral content on social media as part of a learning strategy can be an effective way to attract interest and improve learning outcomes. The virality of Rafael's seblak can be proven through the Tik-Tok platform with the high number of viewers and the audience's enthusiasm for taking part in

making the food. Even Rafael's seblak viewers on the @rafaell_1616 account reached 32.2 million and 28.5 million.

The connection between Seblak Rafael and the physical concepts of temperature and heat can be seen during the cooking process, where there is an application of the concepts of temperature and heat in it. This is what will ultimately become the students' depiction of the material. This approach not only makes the material more relevant, but also makes it easier for students to understand the concepts they encounter. Therefore, researchers are interested in linking food that is going viral with this material. Apart from aligning with social media, researchers also strengthen the use of this project through student survey results. The survey showed that 75.6% of respondents knew about Seblak Rafael, and 85.4% expressed interest in Seblak Rafael which was associated with physics material. Interest arises when individuals feel interested in something, especially if that something suits their needs or is considered meaningful for students (Habibah & Putri, 2023). This shows that students intend to learn it. The high level of interest in Seblak Rafael provides an opportunity for researchers to provide students with a deeper understanding of the concepts of temperature and heat by actively involving them so that learning becomes more memorable. Students' interest in learning is an important factor in the smooth teaching and learning process. Students who have a high interest in learning will support better learning outcomes. On the other hand, low interest in learning will reduce the quality of learning and have a negative effect on student learning outcomes (Habibah & Putri, 2023; Umaroh, 2023). The purpose of this research is to describe the implementation of STEM-PjBL learning through the Seblak Rafael project and the increase in students' scientific literacy after participating in the learning. Therefore, the novelty of this study lies in the integration of viral social media content into the STEM-PjBL framework as a contextual learning strategy.

METHOD

This research used a mixed methods approach with Embedded Design as shown in Picture 1 (Creswell, 2017). In the initial phase of the study, qualitative data were gathered and subjected to analysis in the context of the implementation of STEM-PjBL learning through Seblak Rafael project. The learning process was conducted over three meetings across a three-week period, with the researcher assuming the role of the teacher, a condition that may have implications for the study's objectivity and is therefore considered among its limitations.

It employed a set of learning tools in the form of STEM-PjBL teaching modules, equipped with student worksheets. The implementation of learning was observed by

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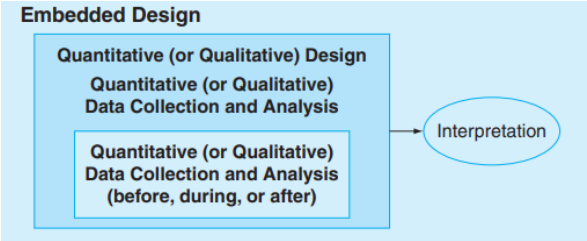
https://doi.org/10.56404/jels.v6i1.246

two observers, who documented the activities of 39 students in Class XI IPA at SMAN 5 Banjarbaru. Furthermore, the observation results were analysed by describing student activities at five stages of STEM-PjBL (initiating with the essential question, designing a plan for the project, creating a schedule, monitoring the student and the progress of the project, assessing the outcome, evaluating the experience). Additionally, the percentage of achievement of the implementation of each STEM-PjBL stage was also analysed with the criteria as shown in Table 1.



Picture 1. Mixed Methods Approach with Embedded Design

Table 1 Percentage of Implementation of STEM-PjBL Stages

Presentation	Criteria
81-100%	Very good
61-80%	Good
41-60%	Enough
21-40%	Not enough
0-20%	Very less

Quantitative data is in the form of students' scientific literacy. This data was collected through a pre-test (before instruction) and a post-test (after instruction). The science literacy test in the form of reasoned multiple-choice questions consists of 10 questions. This instrument has been validated by 3 expert with very high validity (0.81) covering 4 aspects of science literacy, namely competence, context, knowledge and attitude. The test results were then analysed using the N-gain formula with criteria as shown in Table 2. The results of the qualitative and quantitative data analysis were then interpreted to provide information on how the implementation of STEM-PjBL learning with the seblak Rafael project on heat and temperature material can improve students' science literacy.

Table 2 N-Gain Score Criteria

N-Gain Score	Criteria

g> 0,7	High
0,3≤g≤0,7	Moderate
g<0,3	Low

RESULTS AND DISCUSSION

STEM-PjBL is a learning model that implement Project-Based Learning (PjBL) with STEM approach (Science, Technology Engineering and Mathematics) (R. Amelia & Santoso, 2021). Science is the ability to use scientific knowledge and processes to understand nature and the ability to participate in making decisions to influence it (Khalishah & Mahmudah, 2022). Technology is a developed technological knowledge, and has the ability to analyze technology affecting individuals, society, the nation, and the world Engineering is an understanding of technology that can be developed through an engineering/design process using project-based learning themes by integrating several different subjects (interdisciplinary) (Alifa et al., 2018; Xu & Ouyang, 2022). Mathematics is collection in analyzing, reasoning, and communicating ideas effectively and from how to behave, formulate, solve, and interpret solutions to mathematical problems in applying various situations. Implementation of STEM-PjBL according to the integrated stages in the learning process involves a series of systematic steps. The phases in implementing STEM-PjBL carried out by researchers used implementation phases adapted by The George Lucas Educational Foundation. The implementation of STEM-PjBL learning was observed by two observers at SMAN 5 Banjarbaru, the average percentage of implementation of the STEM-PjBL learning phase was 87% with very good criteria. The following describes the activities students engage in at each stage of STEM PjBL learning.

Start with The Essential Question

In this phase, the suitability scale assessed by the observer was 90%, which was included in the very good criteria. Teacher used STEM approach used, Science that is ability to use scientific knowledge (Alifa et al., 2018; Xu & Ouyang, 2022). Learning begins with essential questions, namely questions that prepared by taking topics that are in accordance with real world realities and open questions so as to encourage carrying out activities (Rahmawati, 2022; Ulfa et al., 2019). Students are given videos related to the material and then asked questions.

T: Why do the first and second children experience disparate sensations when situated in the same room? (One child reports feeling hot, while the other reports feeling cold)

S1: The first child is suffering from a fever, whereas the other child has been exposed to external conditions, resulting in a distinct physiological state.

T: What physiological changes occurred in the two children's bodies that resulted in their experiencing different sensations when they were in a room with the same temperature?

S: … (No response from the student)

T: Could you indicate the temperature of the room? What is the appropriate methodology for measuring the temperature of the room?

S2: It is likely that the temperature is below 30 degrees Celsius.

S4: The use of a thermometer is recommended.

Essential questions facilitate students' comprehension of the concepts of temperature and heat. In the subsequent discussion between the instructor and the students following the viewing of video 1, it becomes evident that the students have successfully identified the discrepancies in the conditions experienced by the two children. However, they have been unable to articulate the reasons behind the differences in sensations felt by the two children, which ultimately leads to an explanation of the concept of heat. Based on the findings of this discussion, the instructor proceeded to elucidate the concept of heat, which is defined as a form of energy that flows due to differences in temperature between objects. In the aforementioned dialogue, the students already have the knowledge that the thermometer is a temperature measuring instrument. The teacher proceeds to provide an elaboration on this topic, offering insight into the process of temperature conversion in different types of thermometers.

Design a Plan for the Project

The STEM approach used is namely technology. The role of technology in learning is to facilitate the formation of collaborative relationships (Salsabila & Agustian, 2021). This phase, students preparing project plans is carried out collaboratively between the teacher and students and the planning contains the rules of the game, knowing the tools and materials that can be accessed to help complete the project (Ulfa et al., 2019). The researcher informs the students about the project that will be made, then invites the students to watch the video of seblak Rafael project making on the students' work sheet as a reference for making the project. Students are given time to watch and discuss the video with their group friends and each group is invited to ask questions about tools and materials used. The researcher also explained the agreed project rules, namely that the project was made at school, with some tools and materials provided by the researcher for making seblak chili sauce, according to the group agreement. In this phase, the suitability scale is 95% which is included in the very good criteria.

Create a Schedule

In this phase, a STEM approach is used technology. In this phase, students and teachers collaborate collaboratively prepare a schedule of activities to complete the project (Ulandari et al., 2023). The researcher directs students to make a project schedule and discuss it with the group. In this phase, the conformity scale is 90% which is included in the criteria for very good implementation.

Monitor the Student and the Progress of Project

In this phase, a STEM approach is used engineering and math. Embarrassment which means that students are able to design, apply and collaborate on the results of knowledge and mathematics, which means that students must be able to read symbols in mathematics and be able to solve mathematical problems in everyday life (W. Amelia & Marini, 2022). On this step, The teacher is responsible for monitoring student activities while completing the project. Monitoring is carried out by facilitating students in each process (Rahmawati, 2022; Ulandari et al., 2023; Ulfa et al., 2019). In this phase, the researcher asked the students' readiness first regarding tools and materials, and directed them to start making seblak Rafael project, where each group representative was asked to come forward, while members of each other group made chili sauce and worked on the results of the discussion on the students' work sheet. In this phase, the conformity scale is 85% which is included in the criteria for very good implementation.

Picture 2. Students Cooked Seblak Rafael

Picture 3. Seblak Rafael Made by Students

Assess the Outcome

In this phase, the STEM approach is used engineering and math. Teacher evaluate the student project by providing feedback on the level of understanding that

has been achieved (Rahmawati, 2022; Ulfa et al., 2019). In this phase the researcher directs one group to make a presentation at their respective places. Meanwhile, the other groups, who did not have time to boil crackers to make seblak Rafael project, were assigned to make them at home by presenting them through a video presentation. Following the completion of the Seblak Rafael project and the completion of the assigned practice questions on the provided worksheet, students were able to accurately measure the temperature using a thermometer and calculate the required heat to boil the water prior to boiling the crackers. In this phase, the conformity scale is 80% which is included in the criteria for good implementation.

Evaluate the experience

In this phase, teachers and students reflect on the activities and results of projects that have been carried out. The reflection process is carried out both individually and in groups (Ulfa et al., 2019). In this phase, researchers ask students to express their feelings and experiences during learning and create projects. In this phase, the conformity scale is 80% which is included in the criteria for good implementation. In the closing activity, the researcher asked the students to conclude the learning and the researcher to inform them posttest which the researcher will send after the presentation video is collected, and then close the meeting with greetings. After the video presentation activities are collected, students are given questions in the form of a scientific literacy test.

Researchers conducted a scientific literacy test on 39 class XI science students after conducting STEM-PjBL learning through seblak Rafael project. The researcher gave 10 reasoned multiple choice questions twice, namely pretest (X_0) and posttest (X_t). Researchers use a formula Normalized Gain Score (N-Gain) which is the difference in value between pretest and posttest to show an increase in scientific literacy in classes where STEM-PjBL learning has been carried out (Sukarelawan et al., 2024).

Table 3 Results Pretest and Posttest Learners

No	Code Name	X_0	X_t	$X_t - X_0$	N-Gain	Criteria
	Rate-rate	42.90	73.00	30.10	0.53	Moderate

The analysis results table shows that the average scientific literacy of students after being given pretest and posttest experienced an increase in the medium category, with value N-Gain of 0.53. Apart from that, each aspect of scientific literacy has also experienced an increase which can be seen in the table below.

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https://doi.org/10.56404/jels.v6i1.246

Table 4 Results of Scientific Literacy Aspects

Aspect	Indicator	X_0	X_t	N-Gain	Criteria
Competencies	1. Explain scientific phenomena	70.68	94.87	0,83	High
	2. Evaluate and design scientific investigations	40.00	84.62	0,74	High
	3. Interpreting data and evidence scientifically	27.38	55.23	0,38	Moderate
Contexts	1. Personal	46,79	84,62	0,71	High
	2. Local	38.55	57.44	0,31	Moderate
	3. Global	42,05	73,08	0.54	Moderate
Knowledge	1. Content	47.78	88.89	0.79	High
	2. Procedural	38.46	62.56	0.39	Moderate
	3. epistemic	42.56	68.91	0.46	Moderate
Attitude	1. Interest in science	40.13	69.04	0.48	Moderate
	2. Appreciate the scientific approach to inquiry	39.38	73.85	0.57	Moderate
	3. Environmental Awareness	71.54	84.62	0.46	Moderate

In the scientific literacy aspect table, each consists of three indicators with a score N-Gain highest on each indicator. Competencies in scientific literacy is the ability of students to participate in reasoned scientific conversations, understand scientific phenomena, evaluate and design investigations and interpret data scientifically. This reflects a person's readiness to engage in science and technology discourse with good competence (OECD, 2023). The competency aspect has three indicators. First indicator, explain scientific phenomena with value N-Gain 0.83 is a high criterion. This indicator includes applying appropriate scientific knowledge and making predictions (OECD, 2023; Limiansih & Susanti, 2021; Roy et al., 2025; Wasis et al., 2020). Explaining scientific phenomena in the matter of scientific literacy in this research refers to things that can be observed with the five senses and can be explained scientifically. Second indicator, evaluating and designing scientific investigations, has value N-Gain 0.74 with high criteria. These indicators include identifying questions explored in a particular scientific study and evaluating how to scientifically explore a given question (OECD, 2023; Limiansih & Susanti, 2021; Roy et al., 2025). Evaluating and designing scientific investigations in the matter of scientific literacy in this research involves students' ability to identify, differentiate and evaluate scientific knowledge in everyday life.Third indicator, interpreting scientific data and evidence, has value N-Gain 0.38 with medium

criteria. This indicator includes Transforming data from one form to another and interpreting data and drawing appropriate conclusions. This indicator involves reviewing relevant data based on scientific evidence. From the three indicators studied, the value N-Gain The highest was obtained in the first indicator, namely explaining scientific phenomena.

Aspect context are personal, local and global issues that require an understanding of science and technology. This Aspect has three indicators (Wasis et al., 2020). First indicator namely personal, value N-Gain the personal indicator is 0.71 with high criteria. This indicator is a text or reading that contains events, settings, actions, characters, atmosphere, feelings, ideas or insights that focus on the activities of a person or group. Second indicator is local, value N-Gain 0.31 with medium criteria. This indicator is text or reading that contains events something in the surrounding area. Third indicator is Global, Value N-Gain 0.54 with medium criteria. This indicator is a text or reading that contains events that are global, meaning comprehensive or encompassing From the three indicators studied, the highest N-Gain value is for the personal indicator.

Aspect knowledge is comprised of three indicators, which are necessary for the implementation of scientific literacy competencies. The initial indicator, content knowledge, is represented by N-Gain, which has a value of 0.79 and meets the high criteria. Content knowledge encompasses theoretical, conceptual, explanatory, informational, and factual knowledge situated within personal, local, and global contexts. The second indicator, procedural knowledge, has a N-Gain value of 0.39, indicating a medium level of criteria. The third indicator, epistemic value, has a medium N-Gain value of 0.46. Epistemic value refers to an understanding of the role and function of scientific knowledge in justifying further scientific knowledge. The highest N-Gain value is observed in the content indicator.

The capacity to comprehend, convey and apply scientific knowledge is a crucial aspect of an individual's attitude towards science. This capacity fosters a positive disposition and heightened awareness of one's own and the surrounding environment's nuances, enabling informed decision-making that incorporates scientific insights (OECD, 2023). The aspect attitude is comprised of three indicators. The initial indicator is an interest in science, which is assigned a value of 0.48 on the N-Gain scale, with a medium level of criteria. The second indicator is the value placed on a scientific approach to enquiry, which has been assigned a value of 0.57 with medium criteria. The third indicator is environmental awareness, which has a value of N-Gain 0.46 with medium criteria. Although the mean score on the aspects of attitude falls within the medium range, the indicator with the highest score is appreciation of the scientific approach to

investigation, with an N-Gain value of 0.57. Of the three indicators under examination, the highest N-Gain value is that pertaining to respect for the scientific approach.

The findings of the research conducted thus far indicate that the utilisation of the STEM-PjBL approach in conjunction with the currently viral project, namely Seblak Rafael, can facilitate an enhancement in students' scientific literacy. This viral phenomenon has the potential to enhance students' interest in learning, as the content displayed on social media has been demonstrated to exert a considerable influence on their perceptions and interests (Umaroh, 2023). It can therefore be posited that the utilisation of viral content on social media as part of a learning strategy may prove an effective method of attracting interest and improving student learning outcomes. PjBL learning with a STEM approach incorporates the utilisation of mathematical techniques for the processing of data, in conjunction with technological and methodological applications for the comprehension of scientific concepts within authentic contexts. Such a pedagogical approach is innovative in that students collaborate in groups and develop practical skills that may be readily transferred to situations encountered in everyday life. The findings of this study indicate that students who participated in STEM-PjBL learning through the Seblak Rafael project exhibited a moderate increase in their scientific literacy.

CONCLUSION

The implementation of learning using STEM-PjBL through the Seblak Rafael project yielded highly favourable outcomes, with the percentage of conformity to the implementation of learning reaching 87% and obtained N-Gain 0.53 (medium category). This evidence indicates that the STEM-PjBL learning approach is an effective method for enhancing students' scientific literacy. It is recommended that future research employ larger, more diverse and controlled samples, in addition to assessing long-term retention and transfer. Furthermore, the investigation of other physics topics and grade levels is advised, alongside the employment of qualitative methods to identify which PjBL elements most strongly drive gains.

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