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ARTICLE

Developing STEM worksheets using local food context: Seblak as a tool to teach balanced nutrition

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ABSTRACT

The novelty of this study lies in the development of a Science, Technology, Engineering, and Mathematics (STEM)-based worksheet that integrates the context of Seblak, a popular culinary trend in West Java, Indonesia, as a compelling and relatable medium for teaching balanced nutrition. This concept is essential as foundational knowledge for maintaining health, particularly among students. The study employed the ADDIE instructional design model, encompassing the stages of Analysis, Design, Development, Implementation, and Evaluation. Six experts in STEM education validated the developed worksheet, and 26 pre-service biology teachers participated in the implementation phase to assess its effectiveness. The worksheet was designed in accordance with the steps of the engineering design process, a key feature of STEM learning. The findings indicate that the worksheet is valid in terms of content, integration of STEM components, and language clarity, making it suitable and comprehensible for use by pre-service teachers. Furthermore, the worksheet promoted meaningful learning about balanced nutrition, with students demonstrating creativity above the mastery threshold.

INTRODUCTION

Understanding balanced nutrition is crucial for determining long-term health outcomes. Numerous studies have documented nutrition-related issues (Ebulue, 2025; Ximenes, 2025; Firdaus et al., 2023; Ahsan, 2022; Aquino, 2025). A solid understanding of balanced nutrition and overall health can contribute to improved nutritional quality and well-being. In recent years, malnutrition has become a significant public health concern in Indonesia, with rising rates of both stunting and overweight (Emilia et al., 2022; Nurbaya & Najdah, 2024; Pratiwi et al., 2023). Nutritional adequacy affects not only physical development but also cognitive development, which in turn influences intelligence, thinking skills, and overall productivity. A balanced diet plays a vital role in maintaining overall health, strengthening the immune system, providing sufficient energy, and reducing the risk of chronic diseases such as obesity, diabetes, and cardiovascular disorders later in life (Emilia et al., 2022; Pratiwi et al., 2023).

This highlights the importance of balanced nutrition knowledge for pre-service teachers, as it provides a foundation for effective nutrition education. When teachers engage in nutrition education, they are responsible for enhancing students' knowledge, self-efficacy, and behaviors related to balanced nutrition. This responsibility parallels their role in achieving learning outcomes in science and related disciplines (Nurbaya & Najdah, 2024). Balanced nutrition becomes more engaging when contextualized through contemporary local foods, particularly those popular in West Java. Seblak, a traditional West Javanese snack, is widely favored by various age groups, from adolescents to adults (Atteng et al., 2021). However, its main ingredient, crackers, does not fulfill the principles of balanced nutrition because it is largely composed of carbohydrate-rich components. This nutritional imbalance presents an engaging and challenging context for students to explore and analyze.

An engaging learning experience is essential for fostering a deep understanding of balanced nutrition (Pratiwi et al., 2023). Such experiences help ensure the long-term application of nutritional concepts in daily life. The use of context in learning plays a crucial role in shaping the effectiveness of the learning process. The context of cooking Seblak is particularly compelling because of its popularity, especially in West Java. Learning becomes more enjoyable and meaningful when connected to real-life situations, making knowledge more applicable and relevant to everyday experience (Sulaiman et al., 2024).

One promising approach for teaching balanced nutrition is STEM-based learning. Through this approach, students are presented with the real-world problem of consuming Seblak, a popular dish that does not meet the criteria for balanced nutrition. This context is highly engaging because of its relevance to students' daily lives.

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Based on this issue, students are encouraged to redesign Seblak to meet balanced nutritional requirements, determine appropriate cooking techniques, and calculate its caloric content. This creates an intellectually stimulating challenge as students attempt to reconcile enjoyment of the dish with the principles of balanced nutrition.

Various studies have explored STEM-based learning in different contexts, such as fertilizer production (Mahanan et al., 2022), podcasts for teaching heat transfer (Guden et al., 2024), and flipped learning (Andres & Rosalinda, 2023). Although STEM learning has been widely implemented, no study to date has integrated the context of Seblak cooking into STEM learning to teach balanced nutrition.

To address this research gap, the present study aims to develop STEM worksheets using a Seblak cooking project to help students understand the concept of balanced nutrition. The study addresses the following research questions:

(i) RQ1: What is the validity of the developed STEM worksheet in terms of content, STEM integration, and language, as evaluated by experts?

(ii) RQ2: To what extent do pre-service teachers demonstrate creativity scores above the passing score following implementation of the STEM worksheet in terms of fluency, flexibility, originality, and elaboration?

These worksheets are designed to provide meaningful learning experiences by incorporating stages of the STEM learning. When carefully designed with targeted activities, worksheets can support the development of specific skills (Öztürk, 2021; Purwaningsih et al., 2021). In this context, worksheets serve as a scaffolding tool to guide students in acquiring desired competencies (Muttaqiin et al., 2024; Ramlah et al., 2023). The STEM-based learning experiences embedded in the worksheets are expected to support students (particularly pre-service biology teachers) in developing both conceptual understanding and essential STEM-related skills.

STEM is an approach to teaching science, technology, engineering, and mathematics in which at least two STEM disciplines, one of which is science or engineering, are integrated through STEM practices and authentic content related to students' interests or experiences (Öztürk, 2021). Integrating two or more STEM fields promotes interdisciplinary learning, which is a hallmark of STEM education. This flexibility allows educators to tailor learning programs to available resources and specific learning outcomes without necessarily combining all four disciplines (Halawa et al., 2024; Wu et al., 2024).

STEM education is an important learning experience that contributes to the development of 21st-century skills and other essential abilities. It is also an important component of teacher preparation curricula (Wahono et al., 2020; Kelley et al., 2020; Zhou et al., 2023). STEM learning can cultivate a wide range of skills, including creative thinking (McLure et al., 2022), critical thinking, problem solving, computational thinking, and collaboration (Chiang et al., 2022), while also fostering positive perceptions of STEM fields (Chen et al., 2024; Chun et al., 2024). In addition, STEM experiences allow students to see the interconnectedness of concepts across disciplines, thereby encouraging deeper understanding (Sulaiman et al., 2024).

For example, students may be challenged to design a fly trap to address the problem of flies that disturb humans, using readily available materials. Such experiences provide opportunities for students to think critically and creatively and to solve problems. Student involvement in challenging learning experiences can motivate deeper learning (McLure et al., 2022). Motivation to learn in STEM courses may also increase. Many factors can influence the success of STEM learning, including social factors, motivation, learning strategies, and self-efficacy (Han et al., 2021). These factors should be carefully considered in designing STEM learning experiences.

The advantages of STEM-based learning provide students with opportunities to engage in meaningful learning experiences that foster deep conceptual understanding. Therefore, the development of STEM worksheets based on the context of Seblak cooking is expected to support students in learning about balanced nutrition. Through this contextual approach, students are expected to gain a deeper understanding of balanced nutrition and apply it effectively in their daily lives.

METHODS

Research Design

This study employed a research and development (R&D) design using the ADDIE model, supplemented by a one-group post-test pre-experimental design to assess creativity. In this study, the ADDIE model was used to develop worksheets that facilitate STEM learning. The model consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. In the Analysis phase, we identified the core problems and conducted a needs analysis related to students' understanding of balanced nutrition. The Design phase involved formulating learning objectives, structuring the content, selecting relevant theories, preparing instructional materials, and determining appropriate learning strategies to be integrated into the worksheet. During the Development phase, the STEM worksheet was created by aligning learning activities with the steps of the Engineering Design Process (EDP) to support students in solving nutritional problems associated with Seblak. The Implementation phase involved finalizing the worksheet and applying it in a real learning environment. Finally, in the Evaluation phase, the effectiveness of the developed worksheet was assessed in terms of students' creativity. Further details on this method are provided elsewhere (Susilawati et al., 2025).

The STEM learning experiences facilitated through the worksheets were developed based on the stages of the EDP. The EDP consists of the following steps: (a) identifying a need or problem; (b) researching criteria and constraints; (c) brainstorming possible solutions; (d) selecting the best solution; (e) constructing a prototype; (f) testing; (g) presenting the solution; and (h) redesigning (Moonis Ali, 2014; Nucci et al., 2014).

Research Sample

The worksheet was validated by six experts in science and mathematics education, each with 8 to 15 years of teaching experience. Among them, two held doctoral degrees and four held master's degrees. These experts were selected based on their expertise in their respective fields and their ability to contribute to the development of STEM learning. In the evaluation phase, the validated worksheet was implemented in a classroom setting involving 26 biology pre-service teachers who were enrolled in STEM courses. This stage aimed to assess the practicality and effectiveness of the STEM worksheet in facilitating learning on the topic of balanced nutrition.

Instruments and Data Collection Techniques

The instrument used in this study was an open-ended questionnaire. The questionnaire was divided into Part A (demographic

information) and Part B (evaluation of the worksheet in facilitating STEM learning). Part A contained background information about the validators. Part B contained: (1) 10 open-ended questions on the suitability of the learning strategy used in the worksheet; and (2) items evaluating the content or substance of the worksheet. To determine the effectiveness of the worksheet, an EDP assessment rubric was also used to assess student creativity.

Data analysis

Data analysis in this study covered three components: responses to the open-ended questionnaire, validation of the STEM worksheet, and the effectiveness of the worksheet in enhancing student creativity. Responses from the open-ended questionnaire and the worksheet validation instrument were analyzed descriptively. The percentage of expert responses from the worksheet validation questionnaire was calculated and then interpreted using the validation criteria of very valid, valid, quite valid, and invalid (Julia et al., 2020), as shown in Table 1.

Table 1. Validation criteria.

Obtained score (%)	Effectiveness
80.00 – 100	Very valid
60.00 – 79.99	Valid
50.00 – 59.99	Quite valid
00.00 – 49.99	Invalid

Students' creativity scores after implementing learning with the STEM worksheet were also calculated and compared with the creativity achievement criteria shown in Table 2. Creativity was measured using four indicators: fluency, flexibility, originality, and elaboration. The results were then interpreted using the criteria proposed by Indranuddin et al. (2024).

Table 2. Creativity score criteria.

Score	Remaks
81 – 100	Very creative
61 – 80	Creative
41 – 60	Moderate
21 – 40	Less creative
0 - 20	Not creative

Finally, the creativity test data were analyzed using a one-sample t-test by comparing the obtained scores with a passing score of 70 to determine whether a significant difference existed between students' creativity scores and the passing score.

RESULTS AND DISCUSSION

Analysis Stage

This study aimed to produce student worksheets that facilitate STEM learning. Results of the preliminary study involving several prospective teachers showed that students still had difficulty designing STEM learning experiences. STEM learning is essential, especially for prospective teachers, because it can help them acquire critical competencies such as 21st-century skills. Students also expressed a preference for STEM learning activities that are simple and inexpensive so that they can be implemented easily in practice. The following are excerpts from interviews with students:

> M1: "STEM learning requires expensive learning media, so considerable funding is needed to implement it."
> M2: "I have noticed that STEM is a complicated learning model, making it challenging to implement in schools.".

Design Stage

Based on the identified needs, we aimed to design learning experiences that facilitate accessible STEM learning, even in contexts with limited resources. To support this goal, a STEM worksheet was developed to guide and encourage students to engage in STEM learning. The worksheet served as a scaffold to assist students throughout the learning process and help them perform meaningful tasks aligned with STEM principles (Meilinda et al., 2024). We selected the activity of cooking Seblak to provide students with an engaging and contextualized STEM learning experience. This cooking context was used to foster STEM learning, and the worksheet was designed based on the EDP. The STEM experience integrated relevant STEM disciplines, as depicted in Figure 1. Contextualizing the material helps students connect theoretical concepts to real-world situations, thereby enhancing their understanding of balanced nutrition through the Seblak cooking project (Ramdiah et al., 2020). This allowed students to see the practical application of the balanced nutrition concepts they had learned.

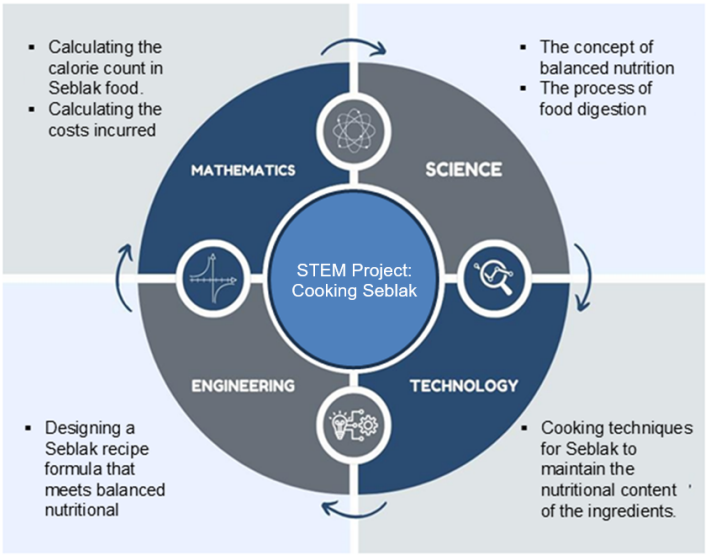

Figure 1: STEM framework applied in the *Seblak* cooking project to teach the concept of balanced nutrition.

Contextualizing learning within real-life situations increases relevance and supports meaningful engagement. For example, nutritional issues related to Seblak can serve as a starting point for teaching balanced nutrition, making learning more meaningful for students. Students are encouraged to design a solution in the form of a Seblak prototype based on their understanding of balanced nutrition. Contextualization facilitates the transfer of knowledge from one situation to another (Ha, 2019; Nurbaya & Najdah, 2024; Ramdiah et al., 2020). Students learning in relevant contexts are more likely to apply their knowledge beyond the classroom (Febrian et al., 2024; Martawijaya et al., 2023). Utilizing local resources in learning is also important (Ruhana et al., 2024). Local resources can make learning richer and more contextual. This approach allows students to strengthen their understanding of the local context, making learning more relevant and meaningful (Ha, 2019). Based on the identified learning needs, a prototype STEM worksheet was then developed. The worksheet was designed by considering the activities students needed to perform. These activities were intended to facilitate pre-service teachers in carrying out STEM learning. The prototype worksheet was then reviewed and validated by expert lecturers, whose suggestions and comments served as the basis for further development

Development Stage

In the development stage, the feasibility of the worksheet in terms of material content, STEM components, and language aspects was validated by six STEM experts (two doctoral degree holders and four master's degree holders). The average validation results are presented in Table 3. The developed STEM worksheet met the criteria of "very valid" for material feasibility (96%), STEM component integration (90%), and language clarity (89%). These results demonstrate that the worksheet is appropriate for facilitating STEM learning on the topic of balanced nutrition.

Table 3. Assessment results by content experts.

Validation aspect	Percentage (%)	Criteria
Material feasibility	96	Very valid
STEM component	90	Very valid
Language	89	Very valid

The development of the worksheet was structured according to the EDP. A contextual problem concerning the nutritional implications of consuming Seblak was presented at the beginning of the worksheet to initiate students' engagement with the EDP. The Seblak context was selected due to its relevance and familiarity to students. Questionnaire results further indicated that 66% of students agreed and 16% strongly agreed that the Seblak cooking project was interesting and enjoyable.

The worksheet was equipped with structured tasks aligned with each stage. The EDP framework included: (a) identifying the need or problem; (b) researching criteria and constraints; (c) brainstorming possible solutions; (d) selecting the best solution; (e) constructing a prototype; (f) testing; (g) presenting the solution; and (h) redesigning (Table 4). These stages served as the foundation for organizing student activities within the worksheet.

The tasks were designed to guide students systematically through each EDP stage and to facilitate active engagement in STEM learning (Figure 2). The worksheet served as a guide for pre-service teachers in formulating and preparing *Seblak* that meets balanced nutrition criteria (Figure 3). Students were required to design *Seblak* formulations, test variations, analyze feedback, and refine their products based on identified limitations.

Student responses indicated that 50% perceived the tasks as clear, 16% as very clear, while 33% suggested that some instructions required further clarification. For example, one student stated that several instructions would benefit from simpler wording (D1), while another suggested that certain tasks should be more explicitly aligned with the corresponding stages (D2). These responses were used to refine the clarity and alignment of the worksheet tasks.

In response to the question, "What kind of Seblak will you make?", 33% of the student teachers stated that the task in the worksheet was unclear, 50% stated that it was clear, and 16% stated that it was very clear.

> D1: "The instructions or tasks in the worksheet are fairly clear, but simpler words are needed in some parts to help students understand."
> D2: "The tasks in the worksheet need to be better aligned with the steps so that they are easier for students to understand and more relevant to each stage."

Clear and precise instructions are essential to ensure that students understand expected tasks and learning objectives (Zulherman, 2019). Therefore, the worksheet employed accessible and standardized language to minimize ambiguity and support comprehension across diverse student backgrounds. Well-structured tasks may also facilitate student engagement and help maintain focus on learning objectives.

The worksheet was designed to support pre-service teachers in conducting authentic STEM learning experiences. Based on questionnaire findings, 66% of students reported that the worksheet helped them carry out STEM learning more easily, and all respondents indicated that participation in the Seblak project contributed to a deeper understanding of balanced nutrition concepts. Furthermore, 66% of students agreed that the STEM learning experience provided opportunities to express creative ideas during the learning process..

The initial tasks in the worksheet presented problems related to balanced nutrition within the context of Seblak consumption. This contextualization enabled students to relate theoretical concepts to real-life situations. Students were encouraged not only to generate solutions but also to analyze processes and evaluate outcomes at each stage. Structured worksheet tasks can help direct learning activities and support the development of higher-order skills, including creativity (Arifah et al., 2022).

Table 4: EDP implemented in the *Seblak* cooking activity.

Steps in EDP	*Seblak* Cooking Activity
Identify a need or a problem.	Students identify the problems associated with consuming Seblak.
Research criteria and constraints	Conduct an investigation related to balanced nutrition Investigate the types of food ingredients for cooking Seblak with balanced nutrition criteria
Brainstorm possible solution.	Group discussion to generate several solutions to solve the problem Students came up with many ideas for Seblak formulations that fulfill balanced nutrition as a solution to the problem
Select the best solution.	Students choose the best Seblak formulation from several available solutions.
Construct a Prototype	Students construct prototypes in the form of Seblak formulations that fulfill the principles of balanced nutrition.
Test	Cooking Seblak by formulating and testing the taste of Seblak to determine the taste of Seblak.

	Exploring testimonials related to the formulation and taste of Seblak made
Present the solution	Identifying testimonials to find out the limitations of cooked Seblak.
Redesign	Reformulate Seblak based on the limitations and what was identified.

Research Criteria/ Constraints

Based on the above context, investigate balanced nutrition and the potential of food ingredients that can be used for Seblak food that fulfills balanced nutrition.

.....

Based on the context of black food and the concept of balanced nutrition, try to design a recipe for black cuisine that is in accordance with this concept, which will prevent various digestive diseases and obesity.

.....

Brainstorm Possible Solution

Tell us as much as possible about the Seblak idea you will create to overcome the above problem by answering the following questions.:

What kind of Seblak will you make?

.....

What is the slogan for the "Seblak" to be made?

.....

Figure 2: Example of worksheet.

Figure 3: The activity of cooking *Seblak*.

Implementation and Evaluation Stage

The effectiveness of the developed STEM worksheet was examined by comparing students' creativity scores with the predetermined passing score of 70 after participation in the project. The distribution of students' creativity levels is presented in Figure 4. As shown in Figure 4, the largest proportion of students fell under the creative category (53.85%), indicating that more than half were able to demonstrate strong creative thinking skills during the learning process. The moderate category ranked second at 38.46%, suggesting that some students still had moderate levels of creativity and room for further development. Meanwhile, the less creative and very creative categories each accounted for only 3.85%, and no students fell under the not creative category. These findings indicate that, overall, the students' level of creativity was generally good.

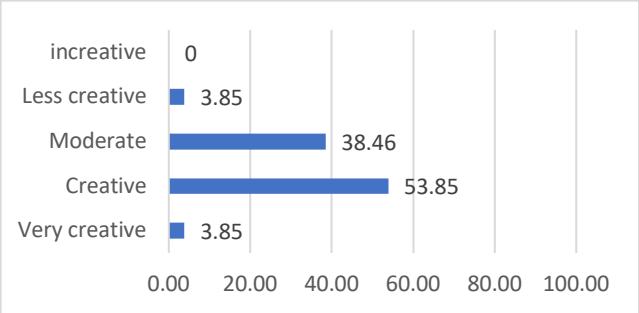

Figure 4: Creativity achievement score based on creativity criteria.

The passing score was determined based on the institutional minimum competency standard, which represents the minimum acceptable level of performance for pre-service teachers in project-based learning activities. Table 5 presents the results of a one-sample t-test comparing students' creativity scores with a passing score of 70. The results indicate that scores for each creativity indicator differed significantly from the passing score criterion. Creativity is a key determinant of success in achieving goals and completing tasks and is an essential requirement for developing individual potential, particularly among prospective teachers.

Learning activities based on the experience of cooking Seblak to facilitate STEM learning required students to seek relevant knowledge actively, think creatively in identifying solutions, engage in group work, and participate in collaborative learning. The findings indicate that collaborative problem-solving tasks enhance student engagement and foster creativity among prospective teachers. In addition to statistical significance, effect sizes were calculated using Cohen's d for the one-sample t-test. The effect sizes ranged from 0.91 to 0.96 across creativity indicators, indicating large practical effects. This suggests that students' creativity performance was substantially above the passing score within the context of this study.

Table 5: One-sample t-test of creativity scores (N = 26, test value = 70, mean = 72.00, 95% confidence interval of the difference)

	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Fluency	4.762	25	< 0.001	12.323	6.99	17.65
Flexibility	4.624	25	< 0.001	11.673	6.47	16.87
Originality	4.712	25	< 0.001	11.962	6.73	17.19
Elaboration	4.875	25	< 0.001	12.923	7.46	18.38

CONCLUSION

The novelty of this research lies in the development of a STEM worksheet based on the local food context of Seblak cooking to facilitate learning about balanced nutrition. The validation results indicate that the worksheet met the criteria for material feasibility, STEM integration, and language clarity. Following implementation, most pre-service teachers demonstrated creativity scores above the predetermined passing score. Statistical analysis showed that the creativity indicators were significantly higher than the benchmark value, with large effect sizes. However, because the study employed a one-group pre-experimental design without a control group, the findings should be interpreted cautiously. The results indicate that participation in the STEM worksheet activities was associated with stronger creative performance within the context of this study rather than providing definitive evidence of causal improvement. Future research using controlled or quasi-experimental designs is recommended to further examine the causal impact of contextualized STEM worksheets on creativity development.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

S. Setiono was the lead contributor and was responsible for securing funding and editing the final manuscript. S. Windyariani was primarily responsible for research data analysis. A. Setiani contributed by providing support and guidance throughout the research.

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