

# Development of a STEM-Based Interactive Module to Improve Nutritional Literacy and Stunting Risk Awareness among High School

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**Abstract:** Stunting remains a major nutritional challenge in Indonesia and is closely associated with low nutritional literacy among adolescents. Schools play an important role in improving students' understanding of nutrition and health through contextual learning. However, biology learning materials are still largely limited to conventional textbooks and worksheets that do not integrate nutritional literacy and stunting issues. This study aimed to develop a STEM-based interactive module on the digestive system to improve nutritional literacy and stunting risk awareness among high school students. The study employed a Research and Development (R&D) approach using the ADDIE model. The participants were 36 Grade XI students at SMA Negeri 7 Makassar. Data were collected through expert validation sheets, teacher and student response questionnaires, nutritional literacy pretest-posttest, and stunting risk awareness questionnaires. The results showed that the module was highly valid (3.80/4.00) and highly practical (3.70/4.00). The module was also effective, as indicated by 94.44% classical learning completeness and a high N-gain score of 0.78 from pretest to posttest results. In addition, students demonstrated a very high level of stunting risk awareness (95.20%). Therefore, the STEM-based interactive module is feasible and effective for improving students' nutritional literacy and awareness of stunting prevention.

**Keywords:** Digestive system; High school students; Nutritional literacy; STEM-based interactive module; Stunting risk awareness

## Introduction

One of the nutritional problems that remains a major challenge in Indonesia is stunting. Stunting is a condition of impaired growth caused by chronic nutritional deficiencies during the first 1000 days of life, resulting in children having a height below the standard for their age (Mitra, 2015). Stunting not only affects physical growth but also has long-term impacts on cognitive development, academic achievement, productivity, and quality of life. Therefore, the prevention of stunting has become an important priority in improving the quality of human resources. The World Health Organization (WHO) has established a global

target of achieving a 40% reduction in the number of stunted children under five by 2025 as part of its commitment to improving maternal and child nutrition (World Health Organization, 2014). In Indonesia, the 2024 Indonesian Nutritional Status Survey (SSGI) reported that the national prevalence of stunting reached 19.8%, indicating that stunting remains a significant public health issue requiring continuous preventive efforts.

Stunting prevention is closely related to nutritional literacy. Nutritional literacy refers to an individual's ability to obtain, understand, and use nutrition-related information to make appropriate decisions regarding diet and health (Syafei et al., 2019). In adolescents,

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nutritional literacy plays an important role because adolescence is a preparatory phase for future adulthood and parenthood. However, studies indicate that Indonesian students' literacy skills are still relatively low, including in understanding health and nutrition information (Pradita et al., 2023). This condition highlights the importance of educational interventions that can improve students' nutritional literacy through contextual and meaningful learning.

In Biology learning, the digestive system topic is closely related to nutrition and health concepts. However, based on observations and interviews conducted with Biology teachers at SMA Negeri 7 Makassar, the learning process still relies heavily on conventional textbooks and printed worksheets (LKPD). The available teaching materials have not integrated nutritional literacy and stunting prevention issues contextually into the learning process. Student questionnaires also showed that learners preferred interactive media and project-based activities because they helped them understand the material more easily and increased learning engagement.

Science, Technology, Engineering, and Mathematics (STEM)-based learning is considered capable of supporting contextual and problem-solving-oriented learning. STEM learning encourages students to integrate scientific concepts with real-life problem-solving activities. STEM literacy is considered one of the essential competencies needed in 21st-century education because it supports problem-solving, critical thinking, creativity, and interdisciplinary understanding (Mulyadi et al., 2026; Zaky et al., 2024). STEM learning has been recognized as an effective approach for developing students' critical thinking, problem-solving skills, and engagement through contextual learning experiences (Effendi et al., 2025). Previous studies reported that STEM-integrated Problem-Based Learning can improve students' critical thinking skills and engagement in science learning (Gusman et al., 2023), and STEM-based learning models such as PBL and PjBL can significantly improve these skills through active and contextual learning experiences (Monika et al., 2023). In addition, STEM-based discovery learning combined with instructional media can improve both conceptual understanding and scientific communication skills (Fikriana et al., 2023). In the 21st century, students are required to master 4C skills, including creativity and collaboration; however, many students still lack these abilities, making STEM-based learning an urgent approach to improve them (Gunawan et al., 2025).

Conventional teaching materials are often less interactive and do not fully support independent learning. Previous studies show that Android-assisted LKPD with a STEM approach can improve students' engagement and critical thinking skills (Taqiyah et al., 2023). In addition, SETS-based interactive e-modules can

improve learning effectiveness by integrating science with environmental, technological, and social contexts (Maria et al., 2024). Maria et al. (2024) also state that interactive e-modules are feasible and practical to use, with high validation results from experts and positive responses from teachers and students. Similarly, Suherman et al. (2025) developed interactive e-modules assisted by Google Sites and found them to be valid and practical for learning, with the potential to improve students' problem-solving skills through interactive and multimedia-based learning.

Although previous studies have developed STEM-based teaching materials, limited studies have integrated nutritional literacy and stunting prevention into interactive Biology learning modules, particularly on the digestive system topic at the senior high school level. Therefore, this study aimed to develop a STEM-based interactive module on the digestive system to improve nutritional literacy and stunting risk awareness among high school students.

## Method

### *Research Location and Subjects*

The research was conducted at SMA Negeri 7 Makassar. The subjects of the study were 36 Grade XI students. The research procedures consisted of expert validation, limited trials, and classroom implementation stages.

### *Research Design*

This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: analyze, design, develop, implement, and evaluate (Branch, 2009; Sutarti et al., 2017). This model was chosen because it provides systematic steps in developing learning products, from needs analysis to evaluation of product effectiveness. The product developed was an interactive Science, Technology, Engineering, and Mathematics (STEM)-based module on the digestive system to improve students' nutritional literacy and awareness of stunting risks.

### *Development Procedure*

The analysis stage was conducted through a needs analysis based on initial observations and interviews with Biology teachers at SMA Negeri 7 Makassar. The findings revealed that the teaching materials used in the learning process were still limited to textbooks and printed worksheets (LKPD), which had not contextually integrated nutritional literacy and stunting issues.

The design stage involved designing the module structure based on Learning Outcomes (CP), Learning Objectives (TP), and the Learning Objective Flow (ATP) integrated with the STEM approach.

The development stage resulted in an interactive module on the digestive system integrated with balanced nutrition and stunting prevention concepts. The module was equipped with illustrations, QR codes linked to digital media such as videos, animations, simulations, and online quizzes, as well as student and teacher guides. The product was validated by subject matter experts and media experts based on the BSNP (2006) standards cited in Panggabean et al. (2020), covering aspects of content suitability, language, presentation, and graphics. Revisions were conducted based on validator suggestions before the limited trial stage.

The implementation stage was carried out through classroom learning activities using the STEM-based interactive module. The learning process applied Problem-Based Learning (PBL) steps integrated with STEM activities, including problem orientation, group discussions, nutritional analysis, project activities, and student presentations. During the learning process, students utilized interactive features such as QR codes, videos, simulations, and online quizzes. Data were collected through nutritional literacy pretests and posttests, stunting risk awareness questionnaires, observation sheets, and teacher and student response questionnaires.

The evaluation stage aimed to assess the validity, practicality, and effectiveness of the developed module. Formative evaluation was conducted through expert validation and limited trials, while summative evaluation was conducted after implementation to measure improvements in students' nutritional literacy and awareness of stunting risks.

#### Research Instruments

The research instruments consisted of validation, practicality, and effectiveness instruments. The validation instrument was an expert assessment sheet developed based on the BSNP (2006) standards as cited in Panggabean et al. (2020). The practicality instrument consisted of teacher and student response questionnaires covering aspects of ease of use, attractiveness, implementation, and usefulness (Oktavia et al., 2024).

The effectiveness instruments included a nutritional literacy test and a stunting risk awareness questionnaire. The nutritional literacy test consisted of 40 multiple-choice questions developed based on the nutritional literacy dimensions proposed by Nutbeam (2000), as cited in Dewi et al. (2023), namely Functional Nutrition Literacy (FNL), Interactive Nutrition Literacy (INL), and Critical Nutrition Literacy (CNL). The questions were also aligned with the cognitive domain of the revised Bloom's Taxonomy proposed by Anderson et al. (2001). Meanwhile, the stunting risk awareness questionnaire used a five-point Likert scale

developed based on the affective domain of the revised Bloom's Taxonomy and the Indonesian Balanced Nutrition Guidelines (Ministry of Health Regulation No. 41, 2014).

#### Data Collection and Analysis Techniques

Validity data was analyzed using the average validator score, with validity categories according to Efendi et al. (2022).

**Table 1.** Validity Level Criteria

Criteria	Validity Category
$3.50 \leq V \leq 4.00$	Very valid
$2.50 \leq V < 3.50$	Valid
$1.50 \leq V < 2.50$	Invalid
$1.00 \leq V < 1.50$	Very Invalid

Instrument reliability was tested using a Cronbach's Alpha coefficient with a criterion of  $\geq 0.70$  (Badruzaman, 2024). Practicality data were analyzed based on the average questionnaire score, categorized according to Ulfa et al. (2022).

**Table 2.** Practicality Level Criteria

Criteria	Practicality Category
3.26 - 4.00	Very high
2.51 - 3.25	High
1.76 - 2.50	Low
1.00 - 1.75	Very low

The effectiveness data were analyzed based on students' mastery of learning outcomes and stunting risk awareness. Learning outcome mastery was determined using the nutritional literacy test with a minimum mastery criterion (KKM) of 75 and a minimum classical completeness level of 80% (Wahyuni et al., 2020). In addition, improvements in students' nutritional literacy were analyzed using the normalized gain (N-Gain) score based on pretest and posttest results. The N-Gain criteria were categorized as high ( $g \geq 0.70$ ), moderate ( $0.30 \leq g < 0.70$ ), and low ( $g < 0.30$ ) according to Hake (Hake, 1999).

Stunting risk awareness data were analyzed using percentage analysis based on the interpretation criteria proposed by Riduwan (2015), as cited in Yenzi et al. (2023). The developed module was considered effective if it achieved the minimum classical completeness criteria and demonstrated a high or very high level of stunting risk awareness.

## Result and Discussion

The STEM-based interactive module on the digestive system was developed using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation.

The analysis stage was conducted through observations and interviews with teachers and students at SMA Negeri 7 Makassar. The findings revealed that Biology learning still relied on conventional textbooks and printed worksheets (LKPD), which were less interactive and had not integrated nutritional literacy and stunting issues contextually. As a result, students' engagement and conceptual understanding were considered limited. Therefore, interactive and contextual teaching materials integrating nutritional literacy and stunting awareness were needed to support meaningful learning.

The design stage involved developing the module structure, analyzing learning tasks, and formulating learning objectives based on Learning Outcomes (CP) and Learning Objective Flow (ATP). The module content covered nutrients in food, the structure and function of digestive organs, digestive processes, digestive disorders, and the relationship between balanced nutrition and stunting prevention. The module was designed with several main components, including a concept map, learning materials, STEM-based activities, practice questions, student worksheets, and user guides. STEM activities included simple experiments, nutritional menu analysis, calculation of nutritional requirements, and the development of stunting prevention campaign projects.

In the development stage, the module was created using the Canva platform and presented in printed and digital (PDF) formats. The module was equipped with illustrations, images, tables, and QR codes connected to instructional videos, animations, simulations, and online quizzes to support interactive learning. Teacher and student guides were also developed to facilitate module implementation. Before implementation, the module underwent formative evaluation and revision based on expert suggestions to improve the quality of the product.

The implementation stage was conducted with Grade XI students at SMA Negeri 7 Makassar through classroom learning activities. The learning process integrated STEM components through scientific exploration, technology utilization, engineering-based project activities, and mathematical calculations related to nutritional needs. Learning activities included group discussions, contextual problem-solving, simple experiments, project activities, and student presentations. During the learning process, students utilized interactive features such as QR codes, videos, simulations, and online quizzes provided in the module.

The evaluation stage aimed to assess the validity, practicality, and effectiveness of the developed module. Evaluation activities included expert validation, observation of learning implementation, teacher and student response questionnaires, and measurement of students' nutritional literacy through pretests and

posttests. The evaluation results indicated that the STEM-based interactive module was feasible for use in Biology learning and supported students' understanding of digestive system concepts, nutritional literacy, and awareness of stunting prevention.

#### *Module Validity*

The validity of the STEM-based interactive module on the digestive system topic was assessed by two expert validators. The validation covered four aspects, namely content feasibility, language, presentation, and graphics.

The validation results showed that the developed module obtained an average score of 3.80, which was categorized as "very valid." This result indicates that the module met the feasibility criteria as a learning material and was suitable for implementation with minor revisions.

**Table 3.** Validity of the STEM-Based Interactive Module

Assessment Aspect	Score	Category
Content Feasibility	3.8	Very valid
Language Feasibility	3.75	Very valid
Presentation Feasibility	3.8	Very valid
Graphic Feasibility	3.85	Very valid
Average	3.8	Very valid

In terms of content feasibility, the module material was considered aligned with the learning outcomes and instructional objectives at the senior high school level. The digestive system topic was integrated with nutritional literacy and stunting prevention concepts to provide contextual understanding for students. The integration of STEM activities was also considered effective in promoting critical thinking, analytical skills, and problem-solving abilities related to nutrition and health issues. This finding is consistent with Permanasari (2016), who stated that STEM-based learning can improve higher-order thinking and problem-solving skills through contextual and investigative learning activities.

The language aspect obtained a score of 3.75, categorized as "very valid." The language used in the module was considered communicative, systematic, and appropriate for senior high school students. Clear instructions and organized learning activities helped students follow the learning process effectively. Communicative language in teaching materials is known to improve readability and facilitate students' understanding of learning concepts (Widianita et al., 2024).

The presentation aspect achieved a score of 3.80, indicating that the module content was systematically organized from introductory materials to STEM-based activities and evaluations. The learning activities were also integrated with Problem-Based Learning (PBL) activities that encouraged discussion, exploration, and collaborative problem-solving. According to Ardianti et

al. (2022), PBL-based learning can support active and student-centered learning processes.

The graphic aspect obtained the highest score of 3.85, categorized as "very valid." The module was designed with a balanced layout, attractive illustrations, and appropriate visual elements to support readability and students' learning interest. The inclusion of QR codes, images, and interactive media also enhanced the attractiveness of the module. Effective visual design in instructional materials can improve students' attention and support conceptual understanding (Wianto et al., 2025).

Instrument reliability was tested using Cronbach's Alpha to determine the internal consistency of the research instruments. The results showed that the student response questionnaire obtained a reliability coefficient of 0.78, the stunting risk awareness questionnaire obtained 0.76, and the learning outcome evaluation test obtained 0.929. All coefficients exceeded the minimum reliability criterion of 0.70, indicating that the instruments had good internal consistency and were suitable for data collection. This finding is supported by Cahyani et al. (2016), who stated that instruments with Cronbach's Alpha values above 0.70 can be categorized as reliable.

#### *Module Practicality*

The practicality of the STEM-based interactive module was determined based on teacher and student response questionnaires administered after the learning implementation. The results showed that the teacher response obtained an average score of 3.80, while the student response obtained an average score of 3.60. The overall average score was 3.70, which was categorized as "very high." These findings indicate that the developed module had a high level of practicality and was easy to implement in the learning process.

The practicality of the module was reflected in aspects such as ease of use, attractiveness, implementation, and usefulness. The module was equipped with clear instructions, systematically organized materials, and interactive visual features that supported both teachers and students during learning activities. The integration of QR codes, videos, simulations, and online quizzes also increased students' engagement and learning interest. This finding is consistent with Maylinda et al. (2021), who stated that the practicality of teaching materials can be identified through users' perceptions of ease of use and usefulness in supporting the learning process.

#### *Module Effectiveness*

The effectiveness of the STEM-based interactive module was evaluated from cognitive and affective aspects. The cognitive aspect was measured through students' nutritional literacy learning outcomes, while

the affective aspect was measured through students' awareness of stunting risks.

Based on the learning outcome test results, most students achieved high learning mastery after participating in learning activities using the STEM-based module. Out of 36 students, 23 students were categorized as "very high" ( $90 \leq \text{TPS} < 100$ ), while 11 students were categorized as "high" ( $75 \leq \text{TPS} < 90$ ). Overall, 34 students (94.44%) achieved the minimum mastery criteria (KKM), whereas only 2 students (5.56%) did not meet the criteria. These findings indicate that the module effectively supported students' understanding of digestive system concepts integrated with nutritional literacy and stunting prevention.

The improvement in students' learning outcomes was further analyzed using the normalized gain (N-Gain) score. The results showed that the average pretest score increased from 45.33 to 87.90 in the posttest, resulting in an N-Gain score of 0.78, which falls into the "high" category. According to Hake (1999), an N-Gain score greater than or equal to 0.70 indicates a high level of improvement. This finding demonstrates that the STEM-based interactive module had a strong positive impact on students' conceptual understanding and nutritional literacy.

The effectiveness of the module was also evaluated from the affective aspect, namely students' awareness of stunting risks. The questionnaire analysis showed a total score of 3,425 out of an ideal score of 3,600, resulting in a percentage of 95.20%. This result indicates a very high level of students' awareness regarding balanced nutrition and stunting prevention after using the module. Thus, the developed module not only improved students' cognitive achievement but also fostered awareness of nutrition and health issues relevant to everyday life.

Overall, the findings indicate that the STEM-based interactive module was effective in improving students' learning outcomes and awareness of nutrition and stunting prevention. This result is consistent with Darlis (2024), who stated that STEM-based learning can enhance student engagement and support conceptual understanding through contextual and real-life learning experiences.

## **Conclusion**

Based on the research findings and discussion, it can be concluded that the STEM-based interactive module on the digestive system topic developed using the ADDIE model was feasible for use in Biology learning. The module demonstrated a very high level of validity with an average score of 3.80/4.00 and a very high level of practicality with an average score of 3.70/4.00, indicating that the module was easy to use and supported the learning process effectively. The

developed module was also effective in improving students' nutritional literacy and awareness of stunting risks. This was indicated by a classical learning completeness level of 94.44% and a high N-Gain score of 0.78. In addition, students demonstrated a very high level of awareness regarding balanced nutrition and stunting prevention, with an awareness percentage of 95.20%. Therefore, the STEM-based interactive module can support students' conceptual understanding while fostering awareness of nutrition and stunting prevention through contextual and integrated learning activities. For future research, similar modules can be developed for other Biology topics or implemented in broader educational settings to examine their effectiveness in improving students' health literacy and learning outcomes.

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