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Development of a digital module based on PjBL to improve critical thinking skills in the science subject of grade 4 at SDN 18 Dodu, Bima City

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Abstract

This research aims to develop a Project-Based Learning (PjBL) digital module to improve the critical thinking skills of fourth-grade students in science subjects at SDN 18 Dodu, Bima City. The Borg & Gall model of Research & Development methods is limited to sixstages: needs analysis, product design, development, expert validation, limited trials, and effectiveness tests. The module is presente dasan interactive flipbook (Canva and Heyzine). The instrumentsare in the form of validation sheets, questionnaires, and pre- and post-test tests. Media experts (score 92%) and subject matter experts (90%) rated the modules "very worthwhile". A practicality test on 10 studentsshowed a "very good" response (88%). Effectiveness testing on 17 studentsobtained an N-Gain of 0.61 (moderate-effective category) which indicatesa significantimprovement in critical thinkingskills. Thus, the PJBL-based digital modules developed are valid, practical, and effectivetoimprovecriticalthinkingskillsin science learning.

Keywords: Digital, Module, *PjBL*, Critical Thinking, Education

1.Introduction

Developing 21st-century skills such as critical, creative, collaborative, and communicative thinking (the 4Cs) is essential in today's education system. To support student-centered learning and provide greater flexibility to educational institutions, the Ministry of Education, Culture, Research, and Technology launched the Independent Curriculum (Kurniawan et al., 2023). This curriculum is designed to respond to the needs of the times, giving teachers the flexibility to determine learning methods that suit student characteristics, and guiding students to be more active, creative, and independent. Unfortunately, field practice shows that traditional teacher-centered teaching methods

still dominate and negatively impact student engagement and critical thinking skills (Sherly et al., 2021; Mastuti et al., 2020). This is where learning that utilizes interactive, flexible, and adaptive digital technology to adapt to individual student needs becomes crucial.

Based on observations and interviews at SDN 18 Dodu, Bima City, it was found that learning of Natural and Social Sciences (IPAS), particularly the plant life cycle topic in fourth grade, was still conducted conventionally. Teachers mostly used lecture methods and traditional teaching media. This condition made students appear passive, less enthusiastic, and tended to have difficulty understanding and connecting the material to their own experiences. Students rarely asked questions and lacked initiative to explore knowledge further. When the learning process is only one-way, students' critical thinking potential cannot develop optimally. Furthermore, the lack of interactive digital modules that are appropriate to the characteristics and learning needs of students is also one of the causes of low critical thinking skills in the class (Field observation data, 2025).

One solution that can be implemented to address these issues is to develop digital modules based on the Project-Based Learning (PJBL) model. PJBL emphasizes learning through authentic and meaningful projects and allows students to play an active role in designing, managing, and evaluating their learning process. Through project stages such as investigations, group discussions, and presentations, the PJBL model has been proven to significantly improve students' critical thinking skills (Suwitu, 2021; Muzijah et al., 2020). In this case, digital-based modules function as both guides and interactive media that teachers and students can use flexibly. Teachers can facilitate students' integration of theory and practice through structured guidance, while students are trained to think reflectively, solve problems, and collaborate to produce tangible products.

This research specifically aims to develop a valid, practical, and effective PJBL-based digital module to improve the critical thinking skills of fourth-grade elementary school students on the plant life cycle. This topic was chosen based on the importance of understanding the concept of plant life from an early age, as well as the great potential of this topic to be linked to students' daily lives. Furthermore, the development of an interactive and contextual digital module is expected to foster deeper cognitive engagement, as explained in Mayer's, (2021). Cognitive Theory of Multimedia Learning. Learning engagement will be optimal if students actively manage visual and verbal information through the process of selecting, organizing, and integrating information into meaningful cognitive structures. The design of a digital module that supports this processing will increase the depth of students' understanding and critical thinking.

2.Methods

The research model used in this study is Research and Development (R&D), which refers to the simplified development of the Borg & Gall model. This model was chosen because it is relevant to the systematic process in educational product development, starting from needs analysis, planning, initial product development, to product evaluation and revision based on validation and trial results (Borg, Gall, & Gall, 2007). The selection of this model aims to produce a digital module based on

Project-Based Learning (PJBL) that is valid, practical, and effective both theoretically and empirically, in accordance with the needs of 21st-century learning that emphasizes the development of critical, collaborative, and project-based thinking skills.

However, to ensure the replication and validity of the study, the justification for the sample size and participant selection criteria are explained as follows: the validation test was conducted by two lecturers as experts, namely a media expert and a material expert. A small group trial was conducted on 10 students, while a field test or large group test was conducted on 27 fourth-grade elementary school students. In addition, 17 students from the large group took a pre-test and post-test to measure the improvement in critical thinking skills after using the module. The participant selection criteria were based on the characteristics of fourth-grade elementary school students that were relevant to the science material and the need for critical thinking development.

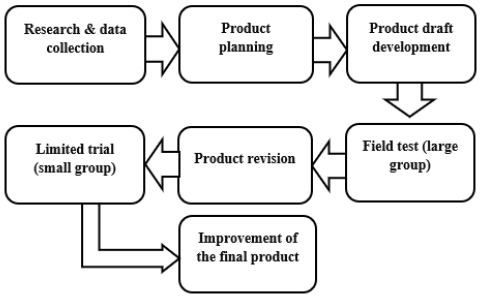
The implementation took place at SDN 18 Dodu, Bima City, with attention to classroom arrangements that supported the use of digital media and brief teacher training prior to implementation to ensure optimal module use.

Ethical aspects of this research were also a priority. Researchers ensured that all participants provided informed consent, either directly from the students or through their guardians. Institutional approval was also obtained from the school as part of administrative and research ethics procedures.

The research instruments used consisted of: (1) a product validation sheet for material and media experts; (2) a questionnaire of teacher responses to the digital module; (3) a questionnaire of student responses to the practicality and attractiveness of the product; and (4) pre-test and post-test questions to measure product effectiveness. Each instrument was designed through relevant theoretical studies and validated by experts. Reliability testing was also conducted to ensure consistency of the results.

Data analysis was conducted using quantitative descriptive methods. Expert validation was presented in the form of average scores and percentages of feasibility. Teacher and student responses were analyzed using Likert scale scores, while product effectiveness was analyzed using the N-Gain score. Although the N-Gain analysis provides a good initial overview of learning outcomes, this study could be strengthened by adding inferential statistical analysis, such as paired t-tests and effect size calculations, to more thoroughly test the significance and strength of the intervention.

Figure 1.
Stages model Borg & Gall



according to Figure 1. The following formula represents the phases of the Bord & Goll development model of data analysis using the percentage descriptive technique:

$$P = \frac{\sum x}{\sum xi} x100\%$$

Table 1.
Criteria for Assessing the Validity of Material and Media Experts

Percentage of scoring results	Information
80 - 100%	Highly deserved
66 - 79%	Proper
56- 65%	Quitefeasible
40 - 55%	Less worthy
30 - 39%	Not eligible

Source (Daryanto, 2016)

Table 2.
Criteria for Teacher and Student Response Effectiveness

Percentage of scoring results	Information
80 - 100%	Highly deserved
66 - 79%	Proper
56- 65%	Quitefeasible
40 - 55%	Less worthy

30 - 39%	Not eligible

Source (Daryanto, 2016)

Researchersused N-Gain calculations toassesshowwell PjBL-based digital modules helped studentsdeveloptheir critical thinking skills. The purpose of this N-Gain analysis wastodetermine how their critical thinking abilities developedafterusinga PjBL-based digital module created by the researchers. The following formula is applied when calculating N-Gain:(Septiana et al., 2022)

$$g = \frac{posttest\ Score\ -\ Pretest\ Score}{Maximum\ Score\ -\ Pretest\ Score}$$

The N-Gain calculation results are categorized using the following criteria in the table:

Table 3.
N-Gain assessment criteria

Nilai	Kriteria
N-Gain ≥ 0,70	Tall
0,30 ≤ N-Gain < 0,70	Keep
N-Gain < 0,30	Low

Source: Hake, R. R. (1998)

3. Result and Discussion

a. Research Results

This study created a digital module based on the PjBL learning paradigm that aids fourth-grade elementary school students in honing their scientific critical thinking abilities. The six phases of the Project Based Learning paradigm basic questions, project planning, schedule creation, progress tracking, testing outcomes, and project evaluation were the basis for the preparation of this digital module. Additionally, the PjBL based digital module is designed to meet the demands of students who still need to work on their critical thinking abilities as well as the autonomy curriculum. This module's layout consists of an interactive flipbook created with the Canva and Heyzine apps. It includes project-based learning guidelines, brief films, formative assessments, and visual elements.

The findings of this study came from the data collection stage conducted at SDN 18 Dodu, Bima City, from May 14, 2025 to June 9, 2025. The development model used in this study is the Bord & Goll model. Research and data collection, product planning, product development, product draft, limited trials (small groups), product revisions, field trials

(large groups), and final product refinements are all processes involved. The following research findings were obtained from the development and research conducted:

1) Data collection and research
In the first stage, classroom teachers are observed, interviewed, and student needsare analyzed. It was found that the critical thinking skills of grade IV science students, especially in understanding information about the life cycle of plants at SDN 18 Dodu, Bima City, are still lacking. In addition, the absence of interactive and contextual digital learning resources makes it difficult for students to relate the material to real-world experiences

2) Product planning
After analyzing the demand, the researcher created a digital module using the PJBL approach from the Independent Curriculum. Planning include selecting interactive flipbook-based media using Canva and Heyzine applications, as well as determining the subject "Plant Life Cycle", learning objectives, and PJBL syntax (6 step).

3) Product draft development
The first iteration of this module was created as an interactive digital flipbook with formative questions, short films, and visual resources. Instructions for executing the project All content uses straightforward language and attractive layouts to meet the needs of elementary school students.

Figure 2.
Cover of PjBL-based digital module

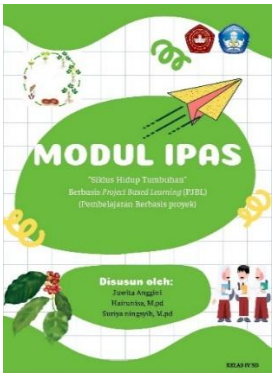


Figure 3.
Digital module learning objective flow

Figure 4.
Digital module learning materials

Figure 5.
Video of the life cycle of green beans

4) Limited trial (small group)
To gather initial feedback, a small group of ten children and a teacher participated in the trial. After that, validation is completed by: Subject matter expert: Before adjustment, the results received a feasibility value of 85%, placing them in the "very feasible" category.
Media specialists: Before the adjustment, the results received an 85% feasibility value, placing them in the "very feasible" category.

5) Product revision
The changes were made in response to feedback from the previous phase. After editing, the validation results increase to:
Subject matter expert: Score increased to 95% (very likely).
Media expert: Improved in visual and learning elements, but remained at 85% (very possible).

6) Field test (large group)
Seventeen students participated in the field test Result:
The average score increased from 45 in the pre-test to 84.17 in the post-test with an N-gain of 0.63 (effective category) for the effectiveness test (pre-test and post-test).

7) Improvement of the final product
The final result is achieved by refining the completeness of interactive features, syntax, and visual elements. This digital module is considered very practical, feasible, and useful for use in teaching science in fourth grade elementary school.

a) Product Validation Results

1) Validation of Subject Matter Experts
Considering the results One of the most important steps in the creation of a learning tool is validation by subject matter experts, which guarantees that the information presented is in accordance with pedagogical principles learning objectives, and relevant competency standards. Mrs. Miftahul Jannah, M.Pd., validated this research as a material expert who has skills in basic education, especially in science subjects and related subjects IPAS.

Table 4.
Results of Recapitulation of Material before revision

Aspects	Acquisition score	Maximum score	Percentage	Category
Fill	26	35	74%	Highly deserved
Serving	15	15	100%	Highly deserved
Language	27	45	82%	Highly deserved
PjBL	20	20	100%	Highly deserved

Total	98	115	85%	Highly deserved

The findings of the evaluation recapitulation are reached during the first step of validation by the materials specialist, as shown in Table 4 above. According to the table, the overall score is 98 out of a possible 115, or 85%, and falls into the "very feasible" category. This evaluation shows that although there are still some areas that need improvement, PjBL-based digital modules have generally met the material substance feasibility requirements and are suitable for use in teaching

Table 5.
Results of the Recapitulation of Material after revision

Aspects	Acquisition score	Maximum score	Percentage	Category
Fill	34	35	97%	Highly deserved
Serving	15	15	100%	Highly deserved
Language	40	45	89%	Highly deserved
PjBL	20	20	100%	Highly deserved
Total	109	115	95%	Highly deserved

The digital module received a 95% feasibility score after revision, falling into the "very feasible" category, according to the validation results, shown in Table 4.2. This shows that the content of the module meets the set quality standards, including suitability with learning objectives, integration of learning materials and activities, and accuracy of language and terminology. The module had received an 85% score prior to the revision, but changes were made based on input from experts, particularly in the project instructions, completeness of examples, and depth of content
Furthermore, content specialist validation evaluates how well the Project Based Learning (PjBL) approach is implemented throughout the curriculum. Basic questions, project planning, scheduling, project implementation, evaluation, and reflection are among the six syntax of PjBL that have been methodically incorporated into the actions and content of the module. This is in accordance with Thomas' (2022) theory which states that PjBL engages students as active learners by having them thoroughly examine real-world problems, resulting in the development of a more sophisticated understanding

2) Media Expert Validation
   Mrs. Nurjumiaty, M.Pd.'s assessment of media experts obtained an average score of 85%, included in the "very good" category. This module is considered aesthetically attractive, easy to use, and conducive to independent and group learning.

Table 6.
Media recapitulation results before revision

Aspects	Acquisition score	Maximum score	Percentage	Category
Display	27	35	77%	Highly deserved

Fill	33	35	94%	Highly deserved
Learning	18	20	90%	Highly deserved
Language	16	20	80%	Highly deserved
Total	94	110	85%	Highly deserved

Based on table 6, the Project Based Learning (PjBL) digital module obtained a total score of 94 out of 110, or 85%, and was classified as "very feasible" in the first round of media validation by media specialists. While these findings suggest that the module can be used, there are still a number of areas that may need improvement, particularly related to language and graphics

Table 7.
Media Recapitulation Results after revision

Aspects	Acquisition score	Maximum score	Percentage	Category
Display	32	35	91%	Highly deserved
Fill	31	35	88%	Highly deserved
Learning	19	20	95%	Highly deserved
Language	19	20	95%	Highly deserved
Total	101	110	85%	Highly deserved

The digital module showsimprovements in almostevery area during the revision process based onrecommendationsfrom media specialists. Because the improvementwasquantitative in some areas and did notchangetheoverall assessment weight, the percentageremained at 85% even though the overall score rose from 110 to 101.

b) Practicality Test

1) Teacher Respon

Table 8.
Results of Teacher Response Recapitulation

Aspects	Acquisition score	Maximum score	Percentage	Category
ATP	24	25	96%	Highly deserved
Module/RPP	42	45	93%	Highly deserved
Module digital	28	35	80%	Highly deserved
PjBL	20	20	100%	Highly deserved
Total	114	125	91,2%	Highly deserved

With a percentage of 91.2%, the project-based digital module obtained a total score of 114 out of 125, included in the "very practical" category, based on table 8 which presents the results of the practicality test based on the teacher's response. This shows that in addition to being practical in terms of media and content, the resulting modules are also simple enough for teachers to use in the teaching and learning process without the need for complicated training or instruction

2) Student Response

Table 9.
Results of the Recapitulation of Student Responses

Number of questions	Acquisition score	Maximum score	Percentage	Category
15	729	750	97,2 %	Highly practical

Based on table 9, the results of the student response questionnaire show that the Digital Project Based Learning (PjBL) module obtained a score of 729 out of a possible 750, or 97.2%, which falls into the "very practical" category. As students are the primary end consumers of these learning products, this achievement is an important metric for evaluating the success of module development

c) Effectiveness Test

To measure effectiveness, pre-tests and post-tests were carried out on 17 students using instruments based on critical thinking indicators

Table 10.
Pre-Test and Post-Test Acquisition of Students

No	Name	Acquisition score		Maximum
		Pre-Test	Post-Test	
1.	AS	41	75	100
2.	RR	47	80	100
3.	F	44	93	100
4.	N	56	100	100
5.	NK	41	83	100
6.	AN	56	80	100
7.	I	39	80	100
8.	K	56	93	100
9.	RFH	39	93	100

10.	G	41	75	100
11.	MA	47	80	100
12.	N	39	80	100
13.	FF	41	83	100
14.	DS	47	83	100
15.	MF	41	80	100
16.	M	34	73	100
17.	N	56	100	100

Table 11.
Pre-Test and Post-Test Recapitulation Results

Pre-test		Post-test	
Acquisition score	Maximum score	Acquisition score	Maximum score
765	1.700	1.431	1.700
Mean		Mean	
45		84,1764705	

The results of the initial trial and the results of the final trial of 17 students who participated in the field trial of the Digital Module based on *Project Based Learning (PjBL*) are presented in Tables 10 and 11. The results of this trial are used to measure the extent to which this module has improved students' critical thinking skills towards the teaching material of the IPAS curriculum about the plant life cycle

In general, the average pre-test score is 45, while the average post-test score has increased significantly to 84.17. Based on the calculation of N-Gain, a value of 0.63 was obtained, which is included in the category of "medium to high" or "effective". This shows that the digital modules developed have a positive and real influence on improving students' critical thinking skills

b. Discussion

The aim of this research is to develop a digital project-based learning module (PjBL) that can enhance fourth-grade elementary school students' critical thinking abilities in science and related topics. This digital module was developed to address the issue of students' poor critical thinking abilities, particularly in science and related topics. The numerous issues pertaining to the poor critical thinking abilities of science students, which were covered in the preceding part, require a fresh finding. One of the innovations developed by researchers is a digital module based on Project Based Learning (PjBL). Based on the findings of the

validity, practicality, and effectiveness assessments, the data indicates that the module is categorized as highly feasible, practical, and effective.

1) Module Eligibility from Expert Validation

After adjustments, the score increased significantly from 85% to 95%, according to validation by material experts. Language and content have improved because they are considered to need to be simpler and more contextual. This supports the findings of Rahayu & Sugiyanto (2020) who stated that modules that are suitable for use in education must meet the requirements of material completeness, correctness of content, and suitability with the characteristics of students

Visual and navigation elements are also improved, according to validation by media specialists, and the overall score remains high at 85%. The module effectively combines interactive features that encourage self-paced learning, responsive design, and engaging visual components. Handayani et al. (2021) support this by claiming that students' interest and focus can be increased both in online and offline learning environments by using well-designed interactive digital media

2) Module Practicality of Teacher and Student Responses
With a score of 91.2%, teachers responded positively to the practicality of the module. Thanks to its structure, ease of use, and alignment with an independent curriculum, this module is considered very beneficial for educators who implement project-based learning. According to research by Utami & Agustin (2022), teachers find it easier to implement active and collaborative learning when modules are prepared systematically using the PjBL strategy.

A large percentage of students who responded (97.2%) stated that the program was engaging, easy to use, and offered an enjoyable educational experience. Fitriyani et al. (2021) claim that because digital teaching materials are interactive and facilitate contextual learning, especially in *Project-Based Learning*, which allows students to learn while doing students are more excited to utilize them

3) Module Effectiveness of Pre-Test and Post-Test
The results of this study indicate that the Project-Based Learning (PjBL) digital module developed using the Borg & Gall model has met the criteria of validity, practicality, and effectiveness. Validation by material experts (95%) and media experts (85%) places the product in the very feasible category. Teacher responses (91.2%) and students (97.2%) also indicate a very high level of practicality. Furthermore, the N-Gain value of 0.63, with a score increase from 45 to 84.17, indicates that this module is quite effective in improving students' critical thinking skills.

These findings align with research by Sari and Dewi (2023), which showed that a project-based approach can increase student active participation and encourage higher-order thinking. Research by Putri et al. (2020) also found that integrating digital technology into project-based learning contributed to increased student engagement and conceptual understanding. Therefore, the results of this study confirm that the Project-Based Learning (PjBL) approach, packaged in the form of digital modules, significantly contributes to the quality of learning at the elementary school level.

Furthermore, this study provides an additional contribution by presenting an interactive flipbook product that can be used flexibly, both independently and collaboratively, and supports student-centered learning. This expands on the findings of previous studies by adding a practical dimension to the context of fourth-grade science learning in elementary school.

However, this study has several limitations that warrant consideration. First, the sample size was relatively small, so generalization of the findings should be approached with caution. Second, the short duration of the trial may not fully reflect the long-term impact of module use. Third, potential bias may arise, given the involvement of teachers and students in the same school context and the influence of initial enthusiasm for a new product. Therefore, further research is recommended to involve more schools and conduct the trial over a longer period to obtain more comprehensive and generalizable results.

4. Conclusion

Considering the findings from the research and development process, a Project-Based Learning (PjBL) digital module designed through the simple stages of the Borg & Gall model, starting from needs analysis to product refinement, has successfully produced an interactive flipbook suitable for use in the context of science learning in elementary schools. The validation results show a very high level of practicality, with a score of 95% from material experts and 85% from media experts. Teacher assessments of 91.2% and students of 97.2% also indicate that this module is very practical, easy to use, and able to facilitate the learning process both individually and in groups.

Furthermore, the increase in the average score of student learning outcomes from 45 to 84.17, with an N-Gain value of 0.63 which is included in the medium to high category, indicates that this module is effective in improving students' critical thinking skills. The implications of these results indicate that the use of PjBL-based digital modules can be directly integrated into classroom learning practices, especially in science subjects, to increase student engagement and understanding through contextual and challenging project-based activities.

In terms of scalability, this module has the potential to be developed and adapted more broadly to other subjects, different grade levels, or implemented in various elementary schools with similar characteristics, both in urban and rural areas. For future research, it is recommended to conduct trials on a larger scale and over a longer period to observe the long-term impact on critical thinking skills, as well as explore the integration of other technologies that support a more interactive and collaborative project-based approach.

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