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Development of a googles site-based science e-module to improve students' learning outcomes and critical thinking on elementary school earth and space material

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ABSTRACT
The low learning outcomes and critical thinking skills of elementary school students are caused by conventional learning methods and limited learning resources. Critical thinking is an important 21st-century skill for students in the digital era. Now, printed teaching materials have shifted to digital form. Innovative, interesting, and interactive teaching materials are needed according to current developments as a solution. The purpose of this study is to develop a Google Sites-based science e-module as a solution to improve valid, practical, and effective learning outcomes and critical thinking skills of students. This development research uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The instruments used were observation sheets, test sheets, and questionnaires. The study was conducted in public elementary schools in Klakah sub-district in 2 meetings. The validation results show that the IPAS e-module has a very high level of validity with an e-module validity value of 89.47% and a material validity of 92.19%, so it is declared suitable for use. This e-module was also declared very practical based on the results of the observation of the implementation of learning at 86.25% and the student response questionnaire at 94.6%. The n-gain data from learning outcomes was 0.6 and critical thinking was obtained at 0.6, both of which have medium criteria. Thus, the development of the e-module of science and technology based on the Google Sites application to improve learning outcomes and critical thinking skills of elementary school students on earth and space material is declared valid, practical, and effective.
Keywords: *ADDIE Model; Critical Thinking; E-module; Google site.*

ABSTRAK
Rendahnya hasil belajar dan keterampilan berpikir kritis siswa sekolah dasar, yang disebabkan oleh metode pembelajaran konvensional dan keterbatasan sumber belajar. Berpikir kritis merupakan keterampilan abad ke-21 yang penting dimiliki siswa di era digital. Era digital seperti sekarang materi ajar berbentuk cetak sudah beralih dalam bentuk digital. Diperlukan materi ajar yang inovatif, menarik, dan interaktif sesuai perkembangan jaman sebagai solusi. Tujuan penelitian ini untuk mengembangkan e-modul ilmu pengetahuan alam dan sosial (IPAS) berbasis *google sites* sebagai

solusi untuk meningkatkan hasil belajar dan keterampilan berpikir kritis siswa yang valid, praktis dan efektif. Penelitian pengembangan ini menggunakan model ADDIE *(Analysis, Design, Development, Implementation, and Evaluation*). Instrumen yang digunakan dalam penelitian ini adalah lembar observasi, lembar tes, dan angket. Penelitian dilakukan di sekolah dasar negeri di kecamatan Klakah dalam 2 kali pertemuan. Hasil validasi menunjukkan bahwa e-modul IPAS memiliki tingkat validitas yang sangat tinggi dengan nilai validitas e-modul sebesar 89,47% dan validitas materi sebesar 92,19%, sehingga dinyatakan layak digunakan. E-modul ini juga dinyatakan sangat praktis berdasarkan hasil observasi keterlaksanaan pembelajaran sebesar 86,25% dan angket respon siswa sebesar 94,6%. Data hasil belajar dan berpikir kritis siswa diperoleh n-*gain* hasil belajar sebesar 0,6 dan berpikir kritis didapatkan sebesar 0,6 yang keduamya masuk pada kriteria sedang. Dengan demikian pengembangan e-modul IPAS berbasis aplikasi *google sites* untuk meningkatkan hasil belajar dan keterampilan berpikir kritis materi bumi dan antariksa siswa sekolah dasar dinyatakan valid, praktis, dan efektif.

Kata Kunci: E-modul; Google site; Model ADDIE; Berpikir Kritis

INTRODUCTION

The learning process in schools begins when the new school year begins. The learning process will conclude with an assessment activity at the end of the school year. One form that can be seen is the report card as a report of learning outcomes. Learning outcomes are the final process achieved in learning activities for a subject. Learning outcomes are a manifestation of students' understanding of the material that has been mastered through learning with the teacher (Muslihudin, 2019). Learning outcomes are a measure of student mastery in following the teaching and learning program according to the objectives (Huda, 2020). Student learning outcomes are often below the qualified minimum competency (KKTP). Research by Waryana (2021) explains that 50% of student learning outcomes do not meet the KKTP because teachers still rely on lecture methods. explain that the learning process influences learning outcomes, requiring the development of supporting teaching materials. The learning process also needs to be supported by innovation in learning. Learning outcomes can be improved by implementing innovative learning (Dwipranoto et al., 2025).

Not only learning outcomes, in the 21st-century learning process, it is necessary to master the 6C skills (critical thinking, collaboration, communication, creativity, culture, and connectivity). These 6C skills include: critical thinking, collaboration, communication, creativity, culture, and connectivity (Montessori et al., 2023). Elementary school is where children's basic skills and knowledge are acquired, honed, and formed. Elementary school is the starting point for students to hone basic skills in intelligence, knowledge, personality, and thinking skills that build mental and knowledge acquisition (Dermawan & Maulana, 2023). One of the important early skills that are useful is critical thinking skills. Aida et al. (2019) also argue that critical thinking is a clear, directed process for solving a problem. Critical thinking is essential in today's digital era. Astutik et al. (2020) explain that critical thinking is a skill that students must have to be successful in today's digital era (Kurino & Herman, 2024).

Critical thinking needs to be facilitated through innovative learning, both in models, media, strategies, and methods. Conventional learning such as rote memorization is no longer relevant for 21st-century learning. Agnafia (2019) research concluded that students' low critical thinking skills are due to learning that tends to require students to memorize, reflected in exam questions that are rote. Similarly, Mareti & Hadiyanti (2021) argue that learning that only requires memorization cannot develop independence in learning, resulting in suboptimal

critical thinking skills. Improving critical thinking skills uses Facione's six indicators. To determine students' critical thinking skills in solving problems, Facione's steps are used: Identify, Define, Enumerate, Analyze, List, and Self-Correct (Munawwarah et al., 2020). These six indicators will be used as indicators of achievement and improvement of critical thinking skills.

Critical thinking skills need to be improved, facilitated by engaging classroom learning. Teachers can create engaging learning experiences by innovating in learning activities, one of which is creating digital modules (e-modules). One effective way to leverage technological advancements in education is through the development of electronic modules (Putri & Reinita, 2023). Developing electronic modules (e-modules) is a relevant solution. Clark & Mayer emphasized that students learn not only from words but also from data and images, so the use of multimedia in learning can optimize students' cognitive processes (Putra & Daulay, 2025). One platform that can be utilized for e-module development is Google Sites, as it can be tailored to student characteristics and learning materials. Google Sites is an application that offers various options for designing teaching materials in the form of classroom learning media according to the needs of students to assist students in online learning (Pratama et al., 2023). Google Sites can facilitate teachers in developing e-modules tailored to student needs and characteristics (Lamadang & Kurino, 2025). The creation and development of Google Sites-based e-modules need to be tested to ensure they meet valid, practical, and effective criteria. Validity, practicality, and effectiveness are necessary in developing e-modules based on Google Sites (Ghozali et al., 2024).

Based on the explanations above, it is necessary to develop a Google Sites-based e-module to improve students' learning outcomes and critical thinking skills, becoming an alternative solution to classroom learning problems. The purpose of this research is to develop a valid, practical, and effective e-module for science and natural sciences (IPAS) based on the Google Sites application to improve learning outcomes and critical thinking skills for elementary school students on earth and space.

METHODS

Type and Design

The type of research used was Research and Development (R&D), with the goal of developing an e-module as a learning resource. The R&D design used was the ADDIE model. The ADDIE instructional model is highly appropriate for developing teaching materials because it is widely used and has a proven track record of high quality. (Cahyadi, 2019).

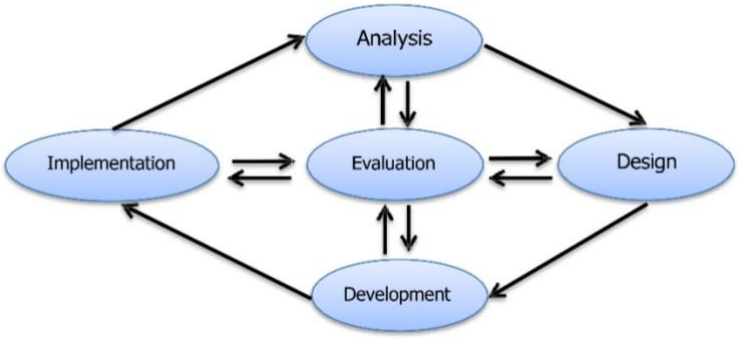

Figure 1 ADDIE Model Stages

The first stage of the ADDIE development model is analysis. This stage involves needs analysis, curriculum analysis, and infrastructure analysis. This is done to identify needs in the field. Information gathering involves adapting the curriculum used at the research school and providing needs analysis questionnaires to teachers and students. The design stage begins with designing the e-module to be developed, focusing on selecting materials to align with the needs analysis. Various references are also collected as a guide in developing the e-module. The development stage involves transforming the design into a reality. Validation by a validator is carried out during the development stage to obtain a valid e-module. The implementation stage involves testing the e-module in small classes after it is declared valid by the validator and suitable for testing. The small class trial was conducted at Sruni 01 Public Elementary School. The final stage is evaluation, which is conducted to assess the quality of the product produced before and after the implementation stage. The implementation stage is limited to implementation in small classes only. Evaluation is also conducted at each stage to determine the extent of the development process at each stage.

Data and Data Sources

The study was conducted during the even semester at three Sruni 01 Public Elementary Schools in Klakah District, Lumajang Regency, during the 2024-2025 academic year. Nineteen students participated in the study, with two learning sessions. In addition to the students, two lecturers from the Faculty of Teacher Training and Education, University of Jember, served as expert validators, assisted by one certified civil servant teacher who served as a practitioner validator. The results of this implementation will determine whether the developed e-module is valid, practical, and effective for use.

Data collection technique

Interviews, questionnaires, observations, and a combination of the three are techniques used in collecting research data (Sugiyono, 2023). Several data collection techniques are described as follows,

a. Observations
   Observations were conducted prior to the research to analyze student and teacher needs. Observations were also conducted during the research by teachers as observers to assess the use of the e-module during learning activities using an e-module implementation observation sheet.
b. The learning outcome test
   The learning outcome test will be conducted in two stages. The first stage is a pretest conducted before learning using the e-module, and the second stage is a posttest after using the e-module. It uses 10 multiple-choice questions adapted to Bloom's taxonomy of cognitive domains as indicators (C1-C6). The cognitive domain in the learning outcome test uses six categories in Bloom's taxonomy (Ndiung & Jediut, 2020).
c. The critical thinking test
   The critical thinking test uses 6 indicators which are given before the learning activity using the e-module as a pretest and then a posttest is carried out after learning using the e-module which is completed by students with a total of 10 essay questions.
d. Questionnaires
   Two types of questionnaires were used. The teacher and student needs questionnaires were used to analyze needs based on existing problems. The student response questionnaire was

administered after the implementation of the science learning activities using the Google Sites-based e-module.

In addition to these collection techniques, in determining the level of validity of the e-module, an e-module validation sheet is used which will be validated by 2 FKIP lecturers and 1 teacher practitioner.

Data analysis

This development research used instruments in the form of an e-module validation sheet, an e-module implementation observation sheet, and a student response questionnaire. The validation sheet was filled out using a Likert scale (Efendi et al., 2021) as shown in the following table 1,

Table 1. Likert Scale Criteria

Rating Scale	Criteria
1	Not Appropriate
2	Less Appropriate
3	Suitable
4	Highly Appropriate

(Source: adopted from Efendi et al. (2021))

Validation will be conducted by two FKIP lecturers and one certified ASN teacher practitioner. The formula for determining validity is as follows,

$$\text{Validity Percentage (V)} = \frac{\text{Total score achieved}}{\text{Maximum total score}} \times 100\%$$

(Source: adopted from Lestari et al. (2024))

The results obtained will be compared with the validity criteria in Table 2 below,

Table 2. E-module Validity Criteria

No	Percentage	Criteria
1	85%<P≤100%	Very Valid
2	75%<P≤85%	Valid
3	60%<P≤75%	Quite Valid
4	1%≥P≤60%	Less Valid

(Source: adopted from Ghozali et al. (2024))

The implementation of e-modules was measured using an e-module implementation observation sheet and a student response questionnaire to see the practicality of the e-modules after learning activities. The results of the e-module implementation observations and student response questionnaires were processed using the following formula,

$$\text{Practicality Percentage (PK)} = \frac{\text{Total score of data collection results}}{\text{Maximum total score}} 100\%$$

(Source: adopted from Jannah et al. (2022))

On the e-module implementation sheet and student response questionnaire filled in using a Likert scale (Efendi et al., 2021), practicality will follow the criteria of table 3 below,

Table 3. Criteria for the E-module Implementation Observation Sheet

No	Percentage	Criteria
1	75%<P≤100%	Sangat Practical
2	50%<P≤75%	Practical

3	25%<P≤50%	Quite Practical
4	0%≥P≤25%	Not Practical

(Source: adopted from Lestari et al. (2018))

A test sheet to test the effectiveness of the e-module by evaluating learning outcomes and critical thinking through pretests and posttests. The pretest and posttest will be used to calculate the n-gain. (Amalia & Novita, 2022). N-gain is obtained by using the following formula,

$$g = \frac{Sf - Si}{Smax - Si}$$

(Source: adopted from Astutik et al. (2020))

The results of the calculations above, the level of effectiveness will be adjusted to Hake's criteria in the following table 4,

Table 4. N-Gain Criteria

N-gain	Criteria
0,7≤*N-gain*	High
0,3≤*N-gain*<0,7	Medium
N-gain<0,3	Low

(Source: adopted from Astutik et al. (2020))

Learning outcomes and critical thinking are considered to have increased when the n-gain is ≥0.3.

RESULTS AND DISCUSSION

This study aims to develop a Google Sites-based science e-module to improve learning outcomes and critical thinking skills in elementary school students' earth and space subjects. The development used the ADDIE model, with the following results and discussion.

1. Analysis Stage

The analysis stage is the main foundation in the ADDIE development model to identify problems and needs of teachers and students. This stage is crucial to ensure the developed solutions are practical and effective. The initial analysis is the analysis of the curriculum, needs, and infrastructure. Curriculum analysis aims to assess learning outcomes and objectives, ensure product development aligns with the applicable curriculum and aligns learning objectives, create teaching modules, design material frameworks, and design appropriate evaluations. Engaging teaching materials in the form of e-modules are a solution to increase student reading interest and replace textbooks. The facilities at the three research schools are adequate to support learning activities. Comfortable classrooms, devices, and internet access are available. All students have devices to access the e-modules. Students without data plans can connect to the school's Wi-Fi, or access hotspots provided by other students or teachers, ensuring smooth learning.

2. Design Stage

The planning stage involved creating an initial draft of the e-module using Google Sites. The initial design took into account information from the analysis phase. The front page provides several main navigation options, such as an introduction, learning outcomes, learning flow, and learning activities. The front page of the e-module can be seen in Figure 2 below.

Figure 2 E-module front page

The introduction contains a foreword, user guide, and author identification. The learning outcomes also explain the learning objectives and criteria for achieving them. The learning flow explains how to utilize the e-module. The learning activities contain materials and evaluation tools. The design is tailored to the needs of teachers and students. The e-module design is made appealing by including images and videos of the material relevant to the learning outcomes and is useful for designing the evaluation sheet at the end.

3. Development Stage

All plans from the design stage are realized in the development stage. This includes development of learning materials, worksheets, and evaluation tools. Learning materials must be developed effectively and efficiently by a teacher (Meilana & Aslam, 2020). Internal testing is necessary at this stage to avoid errors in the use of the e-module. Validation is conducted during the development stage to determine the e-module's feasibility. Validation was conducted by two FKIP lecturers and one practitioner. The results of the e-module expert validation conducted by the two FKIP lecturers are shown in Table 5 below,

Table 5. Summary of Expert Validation Results for E-module

No	Aspect	Validation Score		Average Validation Score
		Validator 1	Validator 2	
1	Visual Appearance	6	8	7
2	Content	16	19	17.5
3	Ease of Use	16	20	18
4	Consistency	6	8	7
5	Graphics	17	20	18.5
Total score		61	75	68
Perscentage		80.26%	98.68%	89.47%
Criteria		-	-	Very Valid

The e-module material was also validated by two FKIP lecturers and one teacher practitioner. The results are shown in Table 6 below,

Table 6. Summary of E-module Material Validation Results

No	Aspect	Validation Score			Average Validation Score
		Validator 1	Validator 2	Validator 3	
1	Content Suitability	18	23	23	21.33
2	Language Suitability	16	20	17	17.67
3	Presentation Suitability	20	20	20	20
Total score		54	63	60	59
Perscentage		84.38%	98.44%	93.75%	92.19%
Criteria		-	-	-	Very Valid

The following comparison of the e-module validation results can be seen in Figure 3. The following E-module validation graph,

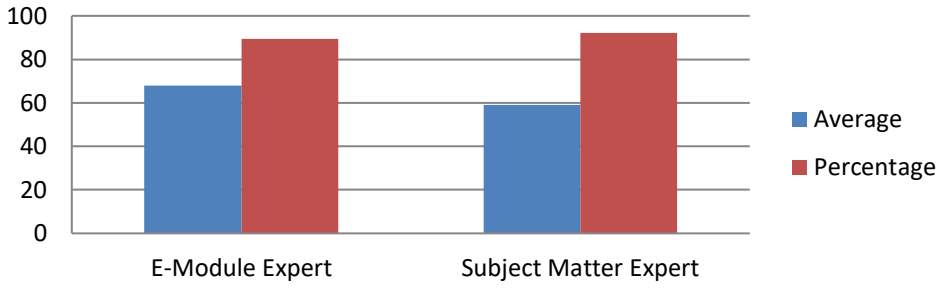

Figure 3 Comparison of E-module Validation Graphs

This module is considered valid based on its visual appearance and consistency, which influence the e-module's superiority. The e-module's visuals are attractive, with clear text and appropriate colors. Images are aligned with learning objectives for easy student understanding. The appropriate layout of images, text, and videos in the e-module supports a high level of validity, supporting improved student learning outcomes and critical thinking. According to Baeng et al. (2022) E-modules are highly beneficial for enhancing students' critical thinking skills and as a resource for independent learning. Validation of e-module materials is carried out for content suitability, language appropriateness, and presentation appropriateness. The images, videos, and audio displayed in the e-modules must be engaging. Sembiring et al. (2021) also confirms that e-modules that are suitable for implementation in the learning process are those with an attractive visual display so that they can create a pleasant learning atmosphere and students can easily understand the material. Implementation Stage

The implementation of learning activities using e-modules in small classes was carried out smoothly. The data obtained were pretest and posttest scores from students' learning outcomes and critical thinking. The obtained scores were analyzed using n-gain and obtained a data recapitulation as follows. Learning outcomes in large classes were categorized as moderate with an average n-gain score of 0.6. This indicates that e-modules improve student learning outcomes. Details of the n-gain scores for learning outcomes can be seen in Table 7 below,

Table 7. N-gain Summary of Student Learning Outcomes

School Name	*Pretest*	*Posttest*	*N-gain*	Criteria
SD Negeri Sruni 01	50.53	81.58	0.6	Medium

Similar to learning outcomes, critical thinking skills were also obtained from the analysis of pretest and posttest scores calculated using n-gain. During the small-class trial, an n-gain of 0.6 was obtained, which is considered moderate, as can be seen in Table 8 below,

Table 8. Recapitulation of Students' Critical Thinking N-gain

School Name	*Pretest*	*Posttest*	*N-gain*	Criteria
SD Negeri Sruni 01	66.32	88.07	0.6	Medium

The effectiveness of the e-module was measured to assess improvements in learning outcomes and critical thinking. The effectiveness of the e-module was analyzed through improvements in students' cognitive learning outcomes and critical thinking skills, as measured by the n-gain scores from the pretest and posttest.

Evaluation Stage

The evaluation stage is not only carried out at the end of the ADDIE stage. Evaluation is carried out at each stage and after full implementation. This is done to assess the quality of the e-module both before and after the implementation stage. The results of observations of the implementation of the e-module by observers obtained an average percentage of 86.25% with the criteria of very practical. The results of observations of the implementation of the e-module confirm that the e-module is practical for learning activities in elementary schools. During learning activities, teachers can use the e-module sequentially and can be followed by students without significant difficulties. The recapitulation of the e-module observations can be seen in Table 9 below,

Table 9. Recapitulation of Observations on the Implementation of the Small Class E-module

No	Observation Aspect	Observation Score	
		Obs. 1	Obs. 2
Preliminary Activities			
1.	The teacher introduces the e-module to students.	3	3
2.	The teacher directs students on how to use the e-module.	3	3
3.	The teacher explains the purpose of using the e-module.	4	4
Main Activities			
4.	The teacher introduces the problem to be studied by students through the e-module.	3	4
5.	The teacher guides students when they encounter difficulties using the e-module during learning activities.	4	4
6.	The teacher assists all groups in using the e-module.	3	4
7.	Students complete the worksheet through the e-module without any problems.	3	3
Closing Activities			
8.	Students conclude learning outcomes through E-modules	3	4
9.	Students work on the evaluation via E-module	3	4
10.	Students convey learning reflections through E-modules	3	4
Total Score		32	37

Percentage	80%	92.5%
Average	86.25%	
Criteria	Very Practical	

The student response questionnaire after using the e-module, in terms of visual and graphical displays, supported high student responses and facilitated student understanding of the material being studied. The attractive visual displays, accompanied by images, videos, and color matching, attracted students' attention. A summary of the student response questionnaire scores can be seen in Table 10 below,

Table 10. Student Response Questionnaire for Small Class E-module

No	Aspect	Acquisition Score	Percentage	Criteria
1.	Visual Appearance	142	93,.42%	Very Practical
2.	Content	65	85.52%	Very Practical
3.	Ease of Use	147	96.71%	Very Practical
4.	Consistency	76	100%	Very Practical
5.	Graphics	137	90.13%	Very Practical
6.	Visual Appearance	152	100%	Very Practical
Total		719	94.6%	Very Practical

The total score obtained was 719 with a percentage of 94.6% and fell into the very practical criteria with all aspects falling into the same criteria.

The visual and graphical aspects achieved a maximum score of 100%. During the learning activities, students were able to easily understand the material, learn independently, and create a pleasant learning atmosphere. This is because the visual display in the e-module has been adjusted to the needs and characteristics of the students and the material being taught, resulting in the best assessment results. The visualization in the Google Sites-based e-module makes it easier for students to learn about earth and space material that is impossible to reach in close and real learning. The Google Sites design, which is adjusted to resemble the display on a smartphone, gives students confidence to use it without hesitation or fear. In addition, the use of Google Sites also provides a positive image that smartphones have a positive impact on student education as a learning tool. The advantages of using smartphones for students include increasing student knowledge, making it easier for students to find information and learning materials (Senge W., 2023).

CONCLUSION

Based on the results of the analysis and discussion, the percentage of validity according to e-module experts was 89.47%, and the validity of e-module material was 92.19%, both of which were in the very valid criteria. In the practicality criteria, the percentage was 86.25%, while the student response questionnaire had a practicality percentage of 94.6%, both of which were in the very practical criteria. For the effectiveness of the e-module, the n-gain of learning outcomes was 0.6 and critical thinking skills was 0.6, both of which were still moderate. From the data obtained, it can be concluded that the development of the e-module of Science based on the Google Sites application to improve learning outcomes and critical thinking skills of elementary school students on earth and space material is valid, practical, and effective so that it is suitable for application in elementary school learning. The research on the development of the ADDIE model for this e-module is still limited to Science learning, which in the next research is expected that this e-module can be applied to all subjects and also added with

innovative learning models so that this e-module can develop according to educational needs. In addition, the condition of Google sites which must always be online presents its own challenges in its implementation, it is hoped that there will be a solution in subsequent research to overcome this challenge.

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