International Journal of Education, Vocational and Social Science
https://e-journal.citakonsulindo.or.id/index.php/IJEVSS
E-ISSN : 2963 4954
IJEVSS

Development Of A Geography E-Module Based On A Deep Learning Approach To Improve Students' Spatial Thinking Abilities At SMAN 1 Bone Pantai

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Abstract

This study aims to develop a geography e-module based on an immersive learning approach and assess its validity, practicality, and effectiveness in improving high school students' spatial thinking skills. The background of this study is the low level of student engagement in the learning process, which is still dominated by conventional methods, resulting in students tending to be passive and less actively engaged. This study used a Research and Development (R&D) method with the development of the Four-D (4D) model. The study was conducted in grade 11 of SMA Negeri 1 Bone Pantai, with data analysis using quantitative descriptive techniques. The results showed that: (1) the developed e-module had a very good level of validity, with a material validation percentage of 83% and a media validation percentage of 93%, making it suitable for use in learning. (2) The e-module's practicality was also very high, as indicated by a student response rate of 92% and a teacher response rate of 96%. This indicates that the e-module is easy to use and well-received in the learning process. (3) Based on the effectiveness test using N-gain, there was an increase in students' spatial thinking skills with a score of 0.71, which is considered high. The trial phase was carried out more widely in four schools in Bone Bolango Regency.

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Keywords: Deep Learning, Disaster Mitigation, Spatial, E-Modules.

INTRODUCTION

An e-module is a systematically designed electronic module that allows students to learn independently without direct teacher supervision. One characteristic of an e-module is self-instruction, meaning it can guide students to learn independently, facilitate access to information, build understanding, develop learning skills, and broaden their horizons according to their learning needs (Abidin & Walida, 2017).

Deep learning is an approach that emphasizes the creation of a conscious, meaningful, and enjoyable learning atmosphere and process through the holistic and integrated development of thinking, feeling, feeling, and physical aspects (Minister of Elementary and Secondary Education Regulation No. 13 of 2025). In this study, the Problem-Based Learning (PBL) model was used, a learning model oriented towards real-world problems to help students develop spatial thinking skills, discover concepts, and solve problems.

According to the Association of American Geographers (AAG, 2008), spatial thinking skills encompass eight indicators: comparison, aura (spatial influence), region, hierarchy, transition, analogy, pattern, and association. Through the PBL model, learning materials can be connected to real-world situations in students' environments, thereby supporting the development of students' spatial thinking skills (Wilson et al., 2020).

Based on interviews with Geography teachers, several challenges were identified in the learning process. Student engagement remains low because learning is predominantly focused on listening and receiving information, resulting in students not actively participating optimally. This situation impacts material comprehension, with some students still experiencing difficulties grasping Geography material. Furthermore, innovative teaching materials in the form of e-modules based on a deep learning approach are not yet available, and teachers have never independently developed modules that could support deeper learning. As a result, the learning implemented has not fully improved students' engagement and spatial thinking skills.

Student observations also revealed several challenges in Geography learning. Students tend to feel bored when learning focuses solely on teacher explanations and textbooks. This indicates a lack of variety in the learning methods and media used. Furthermore, the open-ended materials used do not fully support independent learning. Students desire more engaging, interactive, and accessible learning media, such as flipbook-based e-modules accessible via mobile phones. Based on these challenges, developing Geography e-modules based on a deep learning

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approach that are interactive, structured, and contextual is crucial to support more active and meaningful learning. Therefore, the researcher is interested in developing a research entitled "Development of Geography E-Modules Based on Deep Learning Approach to Improve Students' Spatial Thinking Skills at SMA Negeri 1 Bonepantai." This research has the following objectives: (1) to analyze the validity level of Geography e-modules based on deep learning approaches in improving students' spatial thinking skills at SMA Negeri 1 Bonepantai; (2) to analyze the practicality level of using Geography e-modules based on deep learning approaches in learning to improve students' spatial thinking skills; and (3) the effectiveness of Geography e-modules based on deep learning approaches in improving students' spatial thinking skills at SMA Negeri 1 Bonepantai.

LITERATURE REVIEW

Development Concept

Development is an activity that produces a design or product that can be used to solve actual problems. One approach used in this development is Research and Development (R&D). Research and development is a type of research that can bridge the gap between basic and applied research (Okpatrioka, 2023). Various models can be used in development research, one of which is the 4D model introduced by Thiagarajan (1974). This model consists of four stages: define, design, develop, and disseminate. In developing geography modules, researchers apply the 4D model as a foundation for designing, developing, and refining teaching modules or e-modules that meet student needs (Waruwu, 2024). The stages of 4D model development are presented in Figure 2.1 below.

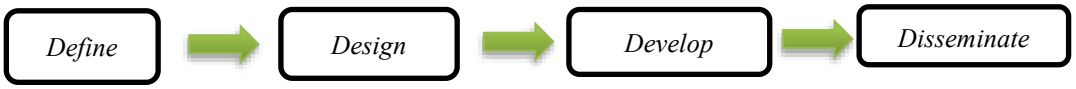


Figure 1. 4D Development Stages

E-Module

Etymologically, e-modules are derived from the words "E" (electronic) and "module." E-modules are electronic-based learning tools that enable students to study material independently (Tanama et al., 2023). E-modules are structured as stand-alone learning materials divided into learning units and presented in digital format. Each activity in the e-module is connected through links as a means of navigation, allowing students to interact more actively with the material presented. (Raqzitya & Agung, 2022). Rusdi (2018) stated that poorly designed learning can lead

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to errors in its implementation. Therefore, e-module design needs to be carried out carefully for effective learning. For students, e-modules make it easier to access and understand learning materials. (Yani et al., 2021). According to Wijayanto, e-modules are a presentation of information in the form of digital books that are stored in electronic media such as hard disks, CDs or flash disks, and can be read via a computer or electronic reader device (Lisyanti, 2019).

Deep Learning

Deep learning is a nurturing approach that emphasizes the creation of a conscious, meaningful, and enjoyable learning atmosphere and process through holistic and integrated thought, heart, feeling, and exercise. Therefore, e-modules need to be designed to be informative but also interactive, contextual, and able to stimulate students' critical reflection, in accordance with the policy direction of Permendikdasmen 13/2025 (Kemendikdasmen, 2025). Minister of Education and Culture Regulation Number 13 of 2025 emphasizes that deep learning is a key principle in curriculum transformation to improve the quality of education in Indonesia. In its implementation, particularly in the development of media such as e-modules, the principle of deep learning must be realized by presenting learning experiences that create awareness, meaning, and reflection for students. The deep learning framework can be seen in Figure 2. below.



Figure 2.2 Deep Learning Framework

RESEARCH METHODS

This research was conducted in class XI of SMA Negeri 1 Bone Pantai located in Bone Bolango Regency, Gorontalo Province. And disseminated in four schools, namely SMAN 1 Suwawa Timur, SMAN 1 Tapa, SMAN 1 Suwawa and SMAN 1 Kabila. The research was conducted on November 24, 2025 – January 27, 2026. This research used the Research and Development (R&D) method with a 4D development model consisting of four stages, namely define, design, development, and dissemination (Waruwu, 2024).

Data analysis is the most important activity in a research, because it can have meaning or

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significance that can be used to solve a problem or answer the research objectives (Slamet Widodo et al., 2020). In this study, the instruments used to assess the feasibility, practicality, and effectiveness of the geography e-module based on the immersive learning approach consisted of validation sheets from subject matter and media experts, teacher and student response questionnaires, and a spatial thinking ability test. All instruments were assessed using a five-point Likert scale, ranging from highest to lowest.

1) E-Module Validity Data Analysis

The data analysis used in the e-module validity test aims to determine the feasibility of the geography e-module based on assessments from subject matter and media experts. This assessment is conducted to ensure that the content, presentation, and appearance of the e-module align with the principles of good teaching materials development and are suitable for use in the learning process.

The formula used by the e-module experts to calculate validity is as follows:

$$Validator = \frac{scores\ obtained}{maximum\ score}\ X\ 100\%$$

The e-module validation eligibility criteria can be seen in Table 1 below:

Table 1. Module Validation Eligibility Criteria

Percentage (%)	Category
81 – 100 %	Very valid
61 – 80 %	Valid
41 – 60 %	Quite valid
21 – 40 %	Less valid

Source : modification (Andayani et al., 2024).

2) E-Module Practicality Data Analysis

Practicality assessment was conducted through a questionnaire completed by teachers and students to obtain their responses and feedback as users of the deep learning-based Geography e-module. This questionnaire was administered after the teachers and students had used the e-module in the learning process. The data obtained were then analyzed to calculate the

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percentage of student and teacher responses using the following formula:

$$\text{Respondents} = \frac{Number\ of\ Student\ Teacher\ Responses}{maximum\ score}\ X\ 100\%$$

The values obtained from the calculations above are then interpreted according to the criteria in table 2.

Table 2 Criteria for Teacher and Student Response Questionnaire

Percentage	Criteria
81% - 100%	Very Practical
61% - 80%	Practical
41% - 60%	Less Practical
21% - 40%	Not Practical
0% - 20%	Very Impractical

Source : Ridwan in (Yulida, 2024).

3) E-Module Effectiveness Data Analysis

Analisis efektivitas bertujuan untuk mengetahui sejauh mana e-modul geografi berbasis pembelajaran secara mendalam efektif dalam meningkatkan kemampuan berpikir spasial siswa pada materi mitigasi dan adaptasi bencana. Data yang diperoleh dianalisis menggunakan metode deskriptif kuantitatif dengan cara membandingkan skor rata-rata pretest dan posttest. Selanjutnya, peningkatan hasil belajar dihitung dalam bentuk persentase menggunakan rumus sebagai berikut:

$$NP = \frac{R}{Sm}\ X\ 100\%$$

Keterangan :

NP : Descriptive percentage (%)
R : Empirical score/obtained score
Sm : Maximum score of the question item

The scores obtained are then classified based on the criteria in Table 3.

Table 3. Criteria for Spatial Thinking Ability

No	Percentage	Criteria
1	91 – 100	Very good
2	81 – 90	Good
3	71 – 80	Currently
4	61 – 70	Low
5	≤ 61	Very Low

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Source : : modification (Viona & Ahyuni, 2024).

The effectiveness of the e-module was measured through written tests administered before and after use (pretest and posttest) to students at SMA Negeri 1 Bone Pantai. Improvement in spatial thinking skills was explained based on the difference in scores between the pretest and posttest. The percentage improvement was then calculated using the following formula:

$$Gain\ Score\ (G) = \frac{S_{Finally} - S_{beginning}}{S_{max} - S_{beginning}}\ X\ 100\%$$

The scores obtained are then classified based on the effectiveness categories presented in Table 4 as follows:

Tabel 4. Kategori Efektivitas

Score	Category
g > 0,7	High
0,3 ≤ g ≤ 0,7	Medium
g < 0,3	Low

Source : modification (Chosya, 2025)

RESULTS AND DISCUSSION

This research resulted in a Geography e-module based on a deep learning approach to improve the spatial thinking skills of eleventh-grade high school students in disaster mitigation and adaptation.

1. Define Stage

This stage was conducted through interviews with geography teachers and students to obtain information regarding challenges encountered in the learning process. Interviews with geography teachers at SMA Negeri 1 Bonepantai revealed that geography instruction utilized various open-ended materials, such as PowerPoint (PPT), videos, images, and printed textbooks provided by the school. However, the use of these teaching materials was not fully effective in encouraging active student engagement and developing a deep understanding of concepts. Furthermore, although the school had implemented the Independent Curriculum (Kurikulum Merdeka), the deep learning approach had not yet been implemented.Interviews with 11th-grade students indicated that students tended to become bored easily when geography lessons were presented in a monotonous manner. Students' baseline abilities were then assessed through a cognitive diagnostic assessment administered prior to the learning process. The results of the students' baseline ability scores can be seen in the appendix, while the distribution of students'

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E-ISSN : 2963 4954
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baseline abilities is presented in Table 5.

Table 5. Distribution of Student Initial Abilities

No	Category	Number of Students	ercentage (%)
1	High	9	30
2	Medium	7	23
3	Low	14	47

2. Design Stage

After the define stage, the next step is to design the product being developed, namely a Geography e-module based on a deep learning approach. Based on the analysis results of the previous stage, an initial e-module design was developed before the product was tested with students. Several initial designs for the Geography e-module based on a deep learning approach are shown in Table 6 below.

Tabel 6 Initial Design of E-Module

Part	Initial Design	
Beginning	Cover	Instructions for use
		
Core (Understanding, applying, reflecting phase)	Material I	Material II
		

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Part	Initial Design	
Penutup	Evaluation 	Glossary 

3. Development

The development stage is the validation stage for the e-module with validators, namely material experts and media experts, and a pilot test using student responses.

a. Validity

This stage involves product validation by material experts and media experts to provide assessments and suggestions for the developed Geography e-module. The material validators were tested by Lecturer Dr. Ramlah Hartini Melo, S.Pd., M.Pd. The final results of the material expert validation data can be seen in Table 7.

Table 7. Results of Material Expert Validation

No	Aspect	Item	Score Max	Score Validity	Level
1	Content	3	12	15	Valid
2	esentation Appropriateness	4	16	20	Valid
3	Languange	3	12	15	Valid
4	E-Module Assessment	5	22	25	Very Valid
Total		**15**	**62**	**75**	**83%**

The second validation, conducted by Rusiyah, S.Pd., M.Pd., was conducted by a media expert. The final results of the media expert validation data are presented in Table 8 below.

Table 8. Media Expert Validation Results

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No	Aspect	Item	Score Max	Score Validity	Level
1	Graphics	4	18	20	Very Valid
2	E-module content design	6	29	30	Very Valid
3	Use of e-modules	2	9	10	Very Valid
4	E-Module Assessment	3	14	15	Very Valid
Total		**15**	**70**	**75**	**93%**

After validation by material and media experts, the e-module underwent a limited trial at SMAN 1 Bone Pantai and a broader trial at four schools in Bone Bolango district.

b. Practicality Testing

The limited product trial phase of this study was conducted by implementing a Geography e-module based on a deep learning approach on disaster mitigation and adaptation to 30 11th-grade students at SMAN 1 Bone Pantai. The practicality results, along with student and teacher responses, are shown in Tables 10 and 11 below.

Tabel 10. Hasil Kepraktisan E-Modul Berdasarkan Respon Siswa

Aspect	Percentage Score	Criteria
E-Module Media Display	93,2	Very Practical
Content	90	Very Practical
Language	93	Very Practical
Rata-rata	**92**	**Sangat Praktis**

Tabel 11. Hasil Kepraktisan E-Modul Berdasarkan Respon Guru

Aspect	Percentage Score	Criteria
Presentation	92	Very Practical
Language	100	Very Practical
Media Display	100	Very Practical
Rata-rata	**96**	**Sangat Praktis**

c. Effectiveness Test

The effectiveness of the Geography e-module based on a deep learning approach was tested by administering a pretest and posttest to 30 eleventh-grade students at SMA Negeri 1 Bonepantai. The pretest was conducted before using the e-module to determine students' initial spatial thinking abilities, while the posttest was administered after the learning process using the

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e-module to determine improvements in these abilities. Furthermore, improvements in spatial thinking abilities were analyzed using the N-Gain test based on the pretest and posttest results. The distribution of spatial thinking ability improvement categories based on the N-Gain test results can be seen in Table 12.

Table 12 Distribution of categories of improvement in students' spatial thinking abilities

No	Kategori N-Gain	Jumlah Siswa	Persentase
1	Tinggi	18	60%
2	Sedang	12	40%
3	Rendah	0	0%
Jumlah		**30**	**100%**
Pretest		**45,17**	
Posttest		**85**	
N Gain Score		**0,718566341**	
Persentase (%)		**71,85663411**	
Kategori		**Tinggi**	

4. Dissemination Phase

At this stage, the Geography E-Module based on a deep learning approach, which has been declared valid and practical, was disseminated to four high schools. The level of practicality based on teacher and student responses from the four schools can be seen in Tables 15 and 16.

Table 15. Teacher Responses at Four Schools

No	School Name	Number of Teachers	Percentage	Category
1	SMA Negeri I Suwawa Timur	1	92%	Very Practical
2	SMA Negeri I Tapa	1	94%	Very Practical
3	SMA Negeri I Suwawa	1	90%	Very Practical
4	SMA Negeri I Kabila	1	96%	Very Practical

Source : Primary data, 2026

Table 4.20 Student Responses in Four Schools

No	School Name	Number of Students	Percentage	Category
1	SMA Negeri I Suwawa Timur	20	89%	Very Practical

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2	SMA Negeri I Tapa	24	77%	Practical
3	SMA Negeri I Suwawa	20	96%	Very Practical
4	SMA Negeri I Kabila	29	90%	Very Practical

The development in this research of the product developed is a limited trial and a broad trial and analysis that has been explained previously, so in this section a discussion is presented regarding the validity, practicality and effectiveness of e-modules based on the deep learning approach to improve students' spatial thinking skills. Nieveen (1999) stated that a learning tool is said to be suitable for use in learning if it meets three criteria, namely valid, practical and effective.

1) Validity of the Geography e-module based on the deep learning approach

The research results indicate that the Geography e-module developed based on the deep learning approach meets the criteria for very good validity. Product validity is demonstrated through assessments by material experts and media experts. The validation results from the material experts yielded a feasibility percentage of 83%. This percentage falls within the 81%–100% range, falling within the "Very Valid" category. This indicates that the aspects of content, presentation, language, and suitability for the deep learning approach and the Problem-Based Learning (PBL) model have been optimally met. The material presented is deemed relevant to the Learning Outcomes of the Independent Curriculum, systematic, and supportive of the development of students' spatial thinking skills. Meanwhile, the validation results from the media experts yielded a 93% score, also falling within the "Very Valid" category. The graphical aspects, content design, ease of use, and integration of the deep learning approach were deemed appropriate for student characteristics. The attractive visual display, systematic layout, and use of contextual illustrations are considered to support student engagement in learning.

2) Practicality of geography based on a deep learning approach

The practicality of the Geography e-module was analyzed through student and teacher questionnaire responses during the limited trial phase. The results showed that the e-module has a very high level of practicality. Based on student responses, a practicality score of 92% fell into the "Very Practical" category. This indicates that students considered the e-module easy to use, visually appealing, and helpful in understanding the disaster mitigation and adaptation material. The e-module, presented in flipbook format, was considered flexible because it can be accessed via mobile devices, thus supporting independent learning. Teacher responses also showed a score of 96%, which fell into the "Very Practical" category. Teachers assessed the e-module as easy to implement in learning, had a systematic material structure, and supported problem-based

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learning activities. Furthermore, the integration of technologies such as Google Forms, Quizizz, and learning videos is considered to facilitate the evaluation and reflection process of learning.

During the dissemination phase at four schools, student responses also ranged from "Practical" to "Very Practical," with percentages ranging from 77% to 96%. This indicates that the e-module is not only practical in one school but can also be applied in other school contexts with different student characteristics. Therefore, the Geography e-module developed based on the deep learning approach can be said to be very practical and easy to use in the learning process.

3) Effectiveness of Geography Based on the Deep Learning Approach

The effectiveness of the Geography e-module was analyzed through improvements in students' spatial thinking skills based on pretest and posttest results, as well as N-gain calculations. The results showed that the average pretest score of 45.17 was categorized as very low, while the average posttest score of 85 was categorized as good. The average increase of 39.83 points indicated a significant change in students' spatial thinking skills after using the e-module.

The N-gain calculation showed an average score of 0.718, or 71.8%, categorized as high (≥ 0.7). This value indicates that the improvement in students' spatial thinking skills was at a high level of effectiveness. Therefore, the developed e-module can be considered effective in improving students' spatial thinking skills.

Based on the overall analysis, it can be concluded that the Geography e-module based on the deep learning approach developed met the criteria of validity, practicality, and effectiveness in improving the spatial thinking skills of 11th-grade students.

CONCLUSION

Based on the research results, the Geography e-module based on the deep learning approach was declared highly valid, practical, and effective for use in Geography learning. Validation results by material experts were 83% and by media experts 93%, with an overall average of 88%, falling into the "Very Valid" category. These results indicate that the developed e-module is suitable for use as an open learning resource. The results of the practicality test showed that the e-module received an excellent response from both teachers and students. Student responses were 92% and teacher responses were 96%, categorized as "Very Practical." This demonstrates that the e-module is easy to use, engaging, and able to make the Geography learning process more interactive and support student independent learning. Furthermore, the effectiveness test results indicated that the Geography e-module based on the deep learning approach was effective in improving students' spatial thinking skills. This was evidenced by an

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increase in students' average score from 45.17 in the pretest to 85 in the posttest, a 39.83 point increase. The N-Gain test results also showed an average of 0.718, which is considered high. Thus, the developed e-module is capable of improving students' spatial thinking skills in geography learning.

FUTURE DIRECTIONS

Based on the research and development results, it is recommended that digital-based teaching materials be continuously developed to improve the quality of learning in schools. The e-modules developed in this research are expected to be optimally utilized in the learning process and serve as a reference for developing other innovative teaching materials. Furthermore, support from various parties is needed to ensure the effective and sustainable implementation of digital-based learning.

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