JPPIPA 11(9) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of E-Modules Based on Differentiated Learning in IPAS Subjects at SMK

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Received: June 08, 2025
Revised: August 10, 2025
Accepted: September 25, 2025
Published: September 30, 2025

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DOI: 10.29303/jppipa.v11i9.12061

Abstract: Education in Vocational High Schools (SMK) faces significant challenges in improving the quality of learning, particularly in Social Sciences (IPAS) subjects that involve abstract concepts, such as Earth and Space. Based on daily test data, only 33.33% of students achieved the Learning Objective Completion Criteria (KKTP), indicating that the majority of students have not yet fully understood the material. This study aims to develop a differentiated learning-based E-Module for the Earth and Space Science material in the IPAS subject at SMKN 8 Padang. The research follows the Research and Development (R&D) method using the Four-D model, consisting of Define, Design, Development, and Disseminate stages. The E-Module was evaluated for validity, practicality, and effectiveness. Results showed that the E-Module achieved high validity, with media receiving 90%, material 81%, and language 100%. The practicality test, conducted with small and large groups, showed scores of 96 and 95%, respectively, while the teachers' evaluation scored 94%. Furthermore, the effectiveness of the E-Module was confirmed with a t-value of 16.293, exceeding the critical value of 2.045, indicating significant improvement in student learning outcomes. The average pretest score was 57.73, which increased to 81.73 after using the E-Module, with a moderate N-Gain score of 57%. These results demonstrate that the E-Module significantly enhances student motivation, understanding, and learning outcomes, making it a viable tool for IPAS instruction in SMK.

Keywords: Differentiated learning; Effectiveness; E-Module; IPAS; SMK

Introduction

Improving the quality of education in Indonesia, coupled with the rapid development of digital technology, requires innovation in learning methods to keep pace with current demands. One education sector facing significant challenges is Vocational High Schools (SMK), which must prepare students with skills relevant to the needs of the workforce. The SMK curriculum, which combines theory and practice, requires a learning approach that facilitates technical skills and develops student competencies (Chen et al., 2022; Hui & Mahmud, 2023). However, conventional teaching, which relies heavily on textbooks, has proven ineffective, particularly in addressing issues of student motivation and learning independence (Lo, 2024; Ruos et al., 2025). Vocational High Schools (SMK) face significant challenges in improving the quality of learning, particularly in Social Sciences (IPAS) subjects that involve abstract concepts, such as Earth and Space. Based on daily test data, only 33.33% of students achieved the Learning Objective Completion Criteria (KKTP), indicating that the majority of students have not yet fully grasped the material (Harris & Clayton, 2019).

One of the main causes is a lack of student engagement and motivation in learning, which still relies on printed textbooks (Cents-Boonstra et al., 2021; Li & Wang, 2024; Meyer et al., 2025). Therefore, more engaging and interactive learning innovations are needed, one of which is the use of e-modules based on

How to Cite:
Yani, F., Bentri, A., Jasrial, & Rahmi, U. (2025). Development of E-Modules Based on Differentiated Learning in IPAS Subjects at SMK. *Jurnal Penelitian Pendidikan IPA*, *11*(9), 330–337. https://doi.org/10.29303/jppipa.v11i9.12061

differentiated learning. These e-modules enable students to learn independently and flexibly, using mobile phones or computers, accessible anytime and anywhere (Eriyanti et al., 2023; Sanova et al., 2022; Sari et al., 2024). With a differentiated approach, the material is tailored to each student's learning style, whether visual, auditory, or kinesthetic, making learning more effective and enjoyable (Niwanggalih et al., 2023; Yotta, 2023). This study aims to develop an e-module based on differentiated learning in the science subject in vocational high schools, with the topic of Earth and Space, which can improve student motivation, understanding, and learning outcomes (Nurhayati et al., 2024; Ruslan et al., 2024; Zhang & Wang, 2021).

The use of the Heyzine application to create interactive e-modules is expected to address challenges in learning and improve student learning outcomes (Setiadi et al., 2024; Vitaya et al., 2025). This research is expected to be a solution to create a more optimal learning experience in the 21st century learning era. It is hoped that this e-module can improve student learning experiences, make learning more flexible, and foster independence in learning (Monib et al., 2025; Resmanti et al., 2024). Based on the diasta background, a study was conducted that aimed to develop a differentiated learning-based E-Module for the Earth and Space Science material in the IPAS subject at SMKN 8 Padang.

Method

This research uses a Research and Development (R&D) method aimed at developing effective products for use in learning. Method is designed to address limitations, solve problems, and produce products that are acceptable to users. This research adopts the Four-D (4-D) development model as its framework. This model consists of four main stages: Define, Design, Development, and Disseminate. This model is used to ensure each stage of product development is systematic and effective. These four dimensions can be explained in Figure 1.

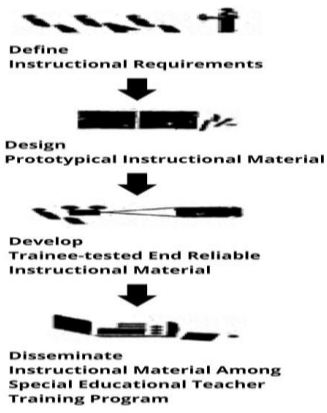

Figure 1. Four-D (4D) steps

This research method uses the Four-D (4-D) development model, which consists of four main stages: Define, Design, Develop, and Disseminate.

Define Stage

In this stage, an analysis of the current curriculum, student analysis, task analysis, concepts, and learning objectives are conducted to determine learning needs and formulate achievement indicators. The main objective is to define materials and methods that are appropriate to student needs.

Design Stage

This stage includes developing test standards, selecting media, selecting presentation formats, and creating an initial design (prototype) of the e-Module. In this stage, learning media are designed to suit student learning styles and the material being taught.

Develop Stage

In this stage, product validation is carried out by material, media, and language experts to ensure alignment with core competencies. Then, a trial is conducted to assess the product's practicality and effectiveness in improving student learning outcomes through pretests and posttests.

Dissemination Stage

After the e-Module is declared valid, practical, and effective, the dissemination stage is carried out to introduce the product to a wider audience, such as teachers and students, for implementation in classroom learning. The Four-D method aims to produce e-Modules that are effective, engaging, and tailored to student needs.

Results and Discussion

The results of this research aimed to develop a valid, practical, and effective differentiated learning-based e-module for the science and science subject in vocational high schools. The e-module development process employed the Four-D model, encompassing four stages of media development: Define; Design; Develop; and Disseminate, Validity, practicality, and effectiveness testing were conducted in accordance with research procedures, seeking the opinions of subject matter, media, and language experts, as well as teachers and students.

Definition Stage

The first stage of this research was an analysis of the field conditions at SMKN 8 Padang related to the Earth and Space science subject. Interviews with teachers revealed that traditional lecture methods and reliance on textbooks hindered student understanding. Therefore,

more interactive teaching materials are needed, such as differentiated learning-based e-modules, to accommodate the differences in student learning styles, in accordance with the characteristics of the Independent Curriculum (Indaryanti et al., 2023). Researchers also conducted student analysis to understand their learning style characteristics. Observations showed that students in class X Kriya 5 have diverse learning styles: 10% visual, 20% auditory, 37% kinesthetic, and the remainder a combination of learning styles. Therefore, e-modules that integrate text, images, sound, video, and animation are expected to help students understand the material according to their learning styles and increase their participation and motivation in learning (El-Sabagh, 2021).

Task analysis was conducted to ensure that the assignments given to students align with the learning objectives of the Independent Curriculum and support understanding of Earth and Space material. The assignments given aim to independently measure understanding and relate the material to everyday life, as well as develop critical thinking skills and the application of concepts in real-life contexts (Retiyanto et al., 2023). Furthermore, concept analysis is conducted to ensure the material taught is structured and supports the achievement of the expected competencies in the Independent Curriculum (Jong et al., 2022). The formulation of learning objectives is based on task and concept analysis to ensure the learning process runs according to the established indicators and helps students achieve competencies effectively (Karlen et al., 2023; Wardoyo et al., 2021).

Planning (Design) Stage

In the second stage of the Four-D (4-D) development model, namely the Design stage, researchers compile various essential components for developing an e-Module based on differentiated learning. This stage includes developing test standards, selecting media, selecting formats, and creating an initial draft. The pretest and posttest consisted of multiple-choice questions structured based on learning outcome indicators to measure students' understanding of the Earth and Space material (Vieriu & Petrea, 2025). The Heyzine flipbook application was selected as the media, which allows the creation of interactive e-modules with animation features, navigation buttons, and the integration of text, images, sound, and video. These e-modules can be flexibly accessed via mobile phones, tablets, and PCs (Latif & Widiaty, 2021). The e-module format was designed to organize the material according to the Learning Outcomes (CP) and Learning Objective Flow (ATP), making it easier for students to understand and master the material (Wasilah et al., 2024).

The next step was the initial design, which began with the creation of a storyboard to outline the flow and design of the e-module. The learning materials were compiled using the Canva platform, converted to PDF format, and imported into the Heyzine application. Each session is designed with a multimodal approach, integrating text, images, videos, and audio recordings to support students' diverse learning styles (Nouri, 2019; Rahmanu & Molnár, 2024). The final stage is the addition of an evaluation page consisting of objective questions integrated with the Wordwall application using QR codes. This evaluation allows students to directly access their learning outcomes and facilitates teachers in monitoring progress (Levy-Feldman, 2025; Schildkamp et al., 2020). Once the e-Module is completed, the PDF file, converted into a flipbook format, is shared via a link for anytime access. Thus, the design stage ensures that the developed e-Module effectively increases student motivation, participation, and understanding of the material (Mahzuardi et al., 2024).

Planning Stage (Design)

The development stage aims to produce valid, practical, and effective e-modules through validation by media, materials, and language experts, followed by practicality testing by teachers and students. Afterward, an effectiveness test is conducted to assess the extent to which the differentiated learning-based e-modules can improve student understanding.

Media Expert Validity

The validity test was conducted by one validator, a lecturer in Educational Technology. The results of the media expert's assessment of the differentiated learning-based e-modules are presented as follows.

Table 1. Media validity

Criteria	Results
Ease of Use	4.43
Visual Appearance	4.33
Media Presentation	4.60
Media Benefits	5.00
Interactivity	4.25
Total	4.52

Based on the validation results by media experts, which covered aspects of ease of use, visual appearance, media presentation, media benefits, and interactivity, an average score of 4.52 was obtained, or 90%, which falls into the "Very Valid" category. Details of the assessment by the media expert validator are as follows.

Validity by Material Experts

Data on material validity were obtained through assessments by material experts, namely lecturers from

the Physics Education Department, using an assessment questionnaire. The assessment covered three main criteria: material relevance, material presentation, and independent practice. The results of the assessment by the material validator are presented in Table 2.

Table 2. Material validity

Criteria	Results
Material Relevance	3.66
Material Presentation	4.00
Independent Practice	4.50
Total	4.05

Based on Table 2, the assessment results of the e-module by the subject matter expert validator indicate that the e-module achieved an average score of 4.05 for material relevance, presentation, and independent practice, with a percentage of 81%, which falls into the "Very Valid" category.

Language Expert Validity

The validity test was conducted by a Language Education Lecturer validator. Assessment criteria included compliance with language rules, sentence suitability, and appropriateness for students. The results of the linguist assessment of the differentiated learning-based e-module are as follows.

Table 3. Language validity

Criteria	Results
Material Relevance	5.00
Material Presentation	5.00
Independent Practice	5.00
Total	5.00

Based on the Table 3, the assessment results of the language expert validator on the e-Module, reviewed based on the criteria of conformity to language rules, sentence appropriateness, and suitability for students, obtained an average score of 5 with a percentage of 100%, thus falling into the "Very Valid" category.

Student Practicality

The practicality test was conducted in two stages: one in small groups and one in large groups. The purpose of this practicality test was to determine the extent to which the e-Module was practical for use by students.

Small Group Practicality Test

This practicality test was conducted by providing the e-Module to three respondents from grade 10 of SMKN 8 Padang. The students then completed a provided questionnaire. The variables assessed in the e-Module included ease of use, material presentation, appearance, and impact on learning strategies.

Based on the Figure 2, the assessments of the differentiated learning-based e-module by three student respondents showed the following results: ease of use 98%, material presentation 98%, visual appearance 93%, and impact on learning strategies 93%. Overall, the practicality test score for the small group reached 96%, categorizing the e-module as "Very Practical" for student use in science lessons.

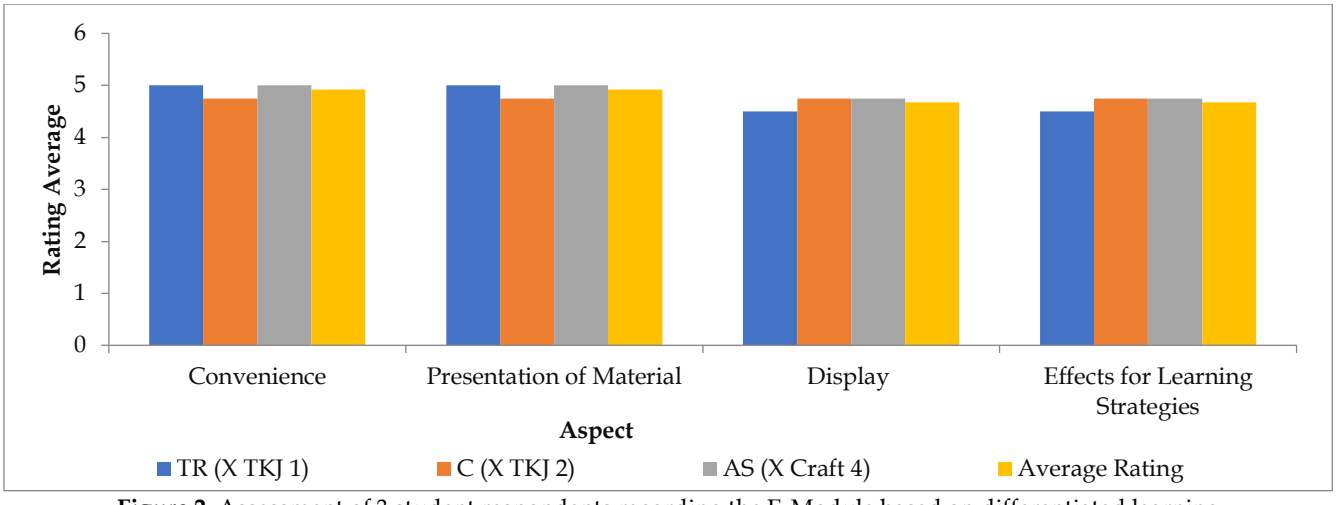

Figure 2. Assessment of 3 student respondents regarding the E-Module based on differentiated learning

Large Group Practicality Test

The practicality test was conducted on 30 respondents from grade X Kriya 5 students at SMKN 8 Padang. The results of the practicality test for the differentiated learning-based e-module are presented in Figure 3.

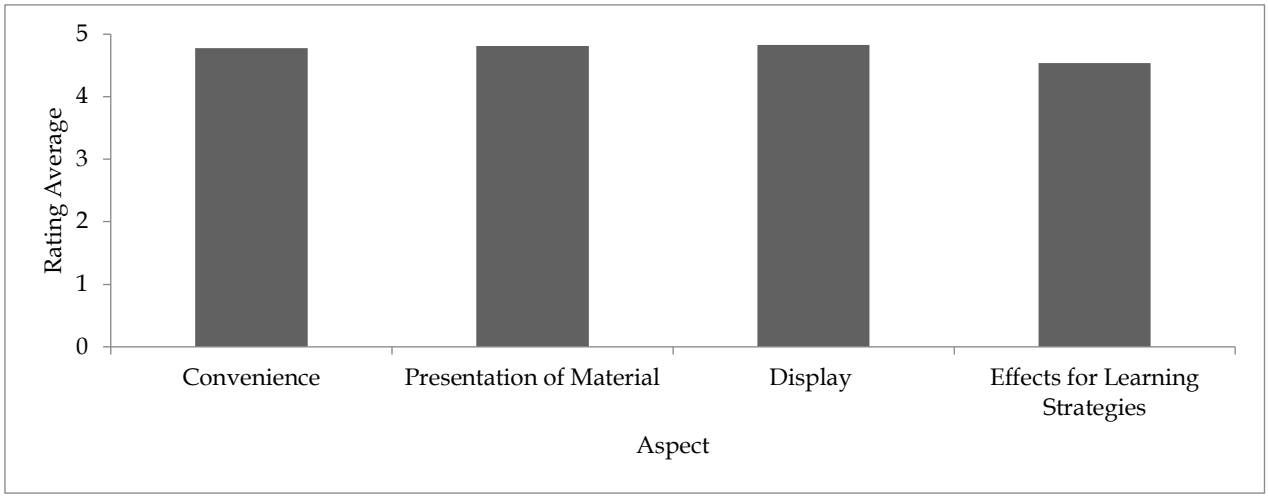

Figure 3. Results of the practicality test of the e-module based on differentiated learning

Based on the Figure 3, the results of the practicality test conducted on the differentiated learning-based e-module show that it received very high ratings from 30 student respondents. Ease of use achieved a 96% rating, material presentation achieved a 96% rating, E-module display achieved a 97% rating, and the E-module's effect on learning strategies achieved a 91% rating. Based on these results, the E-module is considered "Very Practical" for use in the learning process, particularly in science subjects.

Educator Practicality

The educator practicality test was conducted with three educators at SMKN 8 Padang as respondents to assess the effectiveness of the differentiated learning-based e-module in the learning process. The assessment was based on several variables: ease of use, material presentation, display, and impact on learning strategies.

Table 4. Media validity

Criteria	Results
Ease of Presentation	4.20
Appearance	4.67
Effect on Learning Strategies	5.00
Criteria	5.00
Total	4.72

Based on the table, the assessments of three educator respondents regarding the differentiated learning-based e-Module covered four aspects: ease of use, material presentation, appearance, and impact on learning strategies. The assessment results indicate that the overall e-Module received a practicality score of 94%. This score falls into the "Very Practical" category, thus deeming the e-Module suitable and effective for use by educators in science learning.

Media Effectiveness

The final stage was testing the effectiveness of the e-Module using a pretest and posttest. The pretest was administered before students used the e-Module, and the posttest was administered after they had used the e-Module. The effectiveness test results showed a calculated t-value of 16.293, while the calculated t-value with 29 degrees of freedom and a significance level of 0.05 was 2.045. Because the calculated t-value is greater than the calculated t-value (16.293 > 2.045), it can be concluded that there is a significant difference between the pretest and posttest results. Thus, this e-module has proven to be "effective" for use as a teaching material in the science subject at vocational high schools. The comparison of pretest and posttest scores showed an average increase in student learning outcomes from 57.73 to 81.73. After conducting the Gain test, the N-Gain score was 57%, which falls into the "moderate" category. This indicates that the use of the differentiated learning-based e-module has a positive impact on improving student learning outcomes, which aligns with Abad & Hattie (2025); Dulmen et al. (2023); Ribosa & Duran (2022), opinion that teaching materials must consider their effectiveness to improve learning outcomes.

Dissemination Stage

During the dissemination stage, the developed differentiated learning-based e-module was distributed to vocational high school science teachers through the MGMP Science Teachers' WhatsApp group throughout Padang City in the form of a link, ready for use in teaching Earth and Space. Furthermore, the e-module was also disseminated through scientific articles to publicize the results of the development (Syahrial et al., 2022). Following distribution, assessments of the e-Module were collected through a questionnaire distributed using Google Forms. Based on the results,

95% of respondents stated "Strongly Agree" with the quality and appropriateness of the e-Module. The assessment covered aspects of content appropriateness, material presentation, language use, visual presentation, and appropriateness for use in the learning process. These results indicate that the e-Module is considered to be of good quality, easy to use, relevant to the curriculum, and effective in supporting differentiated learning-based science and science learning. Therefore, this e-Module is suitable for widespread distribution and continued use in 10th-grade science and science learning in vocational high schools (Fitriana et al., 2024; Hunaidah et al., 2022).

Conclusion

The development process, from analysis to testing, successfully produced an e-module based on differentiated learning for the tenth-grade science subject at SMKN 8 Padang. This e-module was developed using the Android-based Heyzine Flipbook application, which can be installed by both teachers and students and can be used as learning material both in class and independently at home. The developed e-module was declared "Very Valid" by experts in terms of media, materials, and language. Validation results showed an average media validity score of 90%, material validity of 81%, and language validity of 100%, indicating that this e-module is suitable for use in the learning process.

Acknowledgments
Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions
Conceptualization, methodology, validation, formal analysis, investigation, resources, F.Y.; data curation, writing—original draft preparation, writing—review and editing, visualization, A.B. All authors have read and agreed to the published version of the manuscript.

Funding
Researchers independently funded this research.

Conflicts of Interest
The authors declare no conflict of interest.

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