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Development of Electronic Modules Integrated with PhET Simulation in Physics Subject XII Science Class

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Abstract: This research is motivated by the lack of visualization of abstract concepts, activation of students' senses and the number of damaged electrical kits in Physics causing low understanding of the material. This study aims to produce an E-Module that is valid, practical and effective. The type of research is research and development (R&D) with the ADDIE model. The research process includes analyze, design, development, implementation and evaluation. The sample of this research is XII science class students of SMAN 1 Kejuruan Muda. The data collection technique used was indirect communication technique. The data collection tool used a feasibility questionnaire on media, material and language aspects validated by three validators. Data analysis technique was done with qualitative description. Based on the results of data analysis, the average overall feasibility reached 88.00% (very feasible criteria), and the average practicality of teachers and students reached 96.00% (very practical criteria). The results of the data effectiveness test using one group pre test post test with a cognitive Ngain percentage of 81.39% and a psychomotor Ngain percentage of 76.39% with an effective interpretation. It can be concluded that the E-Module integrated with PhET Simulation can improve the results of concept understanding and students' science skills.

Keywords: E-Module; PhET Simulation; Learning; Physic; XII IPA Class

Introduction

Education is a process to develop self-ability through character building, intellectual improvement and skill development in order to become a qualified individual and have broad potential. Law Number 20 of 2003 states that education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation and state. Education today is characterized by the development of technology that continues to grow in the learning process. Therefore, educational institutions encourage and support educators to take the initiative in educational innovation by designing and developing new practices, methods and applied technologies (Miranda et al., 2021). Technological developments change learning process (Yeni et al., 2019), flexibility of learning that includes how to learn, what to learn, where and when to learn. (Malkawi et al., 2021; Tarman, 2020). Flexibility in the learning process should not deviate from the main objective, which is to significantly improve the quality of learning outcomes (Ula et al., 2023). The current learning approach is centered on student activeness, known as the student centered approach (Naimanova et al., 2023). Therefore, teachers have an important role to facilitate teaching materials that are in accordance with the material and characteristics of students so that learning outcomes can be achieved properly.

Teaching materials are one of the main elements in the learning process that students use to learn (Tatli et

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al., 2023). The main objective in developing teaching materials is to improve the efficiency and effectiveness of the teaching-learning process in achieving learning objectives and improving students' cognitive, affective, and psychomotor aspects (Maksum & Purwanto, 2022).

Physics is part of natural science. In learning physics, there are several concepts that are abstract, often difficult for students to understand, and require a long time to ensure their understanding of the concept (Hakim et al., 2022; Nurdini et al., 2022). Physics material that is abstract in nature is what makes students must be able to understand concepts rather than just memorizing formulas (Nabilah & Jumadi, 2022) and must also be able to relate those concepts to the real world (Herayanti et al., 2022) to solve the problem in life (Saputra & Mustika, 2022).

However, in reality, physics materials have not been equipped with adequate visualization, so students have difficulty imagining and understanding the application of these concepts in real situations. Therefore, concretization of learning is needed to visualize these abstract materials so that it can deepen students' understanding of concepts. In addition, experimental activities are also needed to prove the theory, enrich the learning experience and improve students' science process skills.

This statement is in line with the results of initial observations made at SMAN 1 Kejuruan Muda. The observation results show that students rarely get practical experience related to electricity. This is due to the limitations of electrical experimental kits and the sensitivity of electrical equipment that is easily damaged, as well as safety considerations against electrical hazards. This condition is a factor in the low learning outcomes of Physics direct current electricity material due to a lack of learning experience (Almulla, 2020; Parker et al., 2022) which results in the quality of student understanding being low.

These problems can be overcome by carrying out virtual practicum activities. There are many types of virtual practicum that can be used in direct current electricity materials such as tinkercard circuit, circuit lab and phet simulation. Tinkercard and circuit lab have shortcomings, namely web-based so that they can only be used online. In addition, virtual practicum using tinkercard and circuit lab only focuses on electrical material and cannot be used in other physics materials. However, phet simulation can be used online and offline (Azhar et al., 2024) and can be used on many physics materials. Apart from that, there are other advantages to using PhET, namely being able to provide an overview of abstract phenomena in physics that are difficult to observe directly with the human senses, which is possible and easier with PhET simulations (Imaniah et al., 2023). This statement is consistent with Arisandy et al (2021) PhET Simulation has the ability to transform abstract concepts into more concrete ones through visual representation of object movement so that PhET simulation can make it easier for students to understand (Susilawati et al., 2022).

Other problem found at SMAN Kejuruan Muda are the lack of effort from teachers to develop teaching materials that can activate students' senses. The E-Module is still static and does not cause interaction so that learning takes place in one direction and students do not actively participate. This hinders their in-depth understanding of concepts due to the lack of sensory tools used by students to learn, resulting in limited retention of student information.

According to Khotimah et al (2019) The more senses students utilize to obtain information, the greater the chance that the information will be remembered by students. Using e-modules allows students to be involved in more than one sense (Susanti et al., 2023). This opinion is in line with research conducted by Nurhidayati et al (2018) e-modules involved more than one sense because equipped with video, audio, image and animation that help students to increase their knowledge and understanding in learning. E-Modules can be used as self-study materials organized into small learning units to achieve learning objectives (Etanastia et al., 2022). E-modules can also facilitate various learning styles and ability levels of students (Yevira et al., 2023). E-Modules was chosen because it has self-instruction and self-contained characteristics (Saputri et al., 2023) so that it can provide more time for students to learn the material taught independently (Asih et al., 2022; Basit & Suhartini, 2023; Dini et al., 2023). Therefore, the practicum and learning activity guide are packaged in an E-Module.

The situation of SMAN 1 Kejuruan Muda is very supportive of making E-Modules integrated with PhET Simulation because almost 90% of students have mobile phones and the school allows them to bring mobile phones, the availability of lcd projectors in each class and smartboards in the physics laboratory.

Based on the explanation above, it is necessary to develop teaching materials in the form of E-Modules integrated with PhET Simulation. The development of E-Modules integrated with PhET Simulation is important to increase student engagement and motivation in the learning process (Sabaruddin et al., 2023). By integrating this simulation into the e-module, students can gain a deeper and more concrete understanding of physics concepts that are abstract and difficult to understand.

Several studies that have been conducted previously reveal that E-Modules aim to increase students enthusiasm and interest in learning, help

facilitate and simplify the learning process, and provide diverse visualizations to better understand learning materials (Permadi & Novrianti, 2023). In addition, This opinion is in line with research conducted by Yayang (2019) E-Modules are a step to add relevant learning resources and allow students to learn independently. In addition, E-Modules can increase learners' psychomotor skills (Purba & Sujatmiko, 2023). So based on some previous research results, it can be said that E-Modules integrated with PhET Simulation has various positive benefits in improving students' cognitive abilities and psychomotor skills.

The problem to be studied in this article is the development of E-Modules integrated PhET Simulation in Physics Class XII IPA. The purpose of this research is seen from several aspects, namely aspects of validity, practicality and effectiveness of E-Modules in Physics Subjects. This article introduces a new approach in the pedagogical design that connects theory with practice through simulation. This e-module not only provides concept explanations but also provides relevant simulation experiences, allowing students to visualize and experiment with physics concepts in a virtual environment integrated directly in the e-module.

Method

This research uses the Research and Development (R&D) method. The Research and Development (R&D) method is a type of research that aims to develop products and test the effectiveness of these products, starting from analyzing needs to conducting product trials so that they can be widely applied, especially in the context of education in schools (Sugiyono, 2014). The test subjects in this study were students in Physics Class XII IPA 1 odd semester of the 2024-2025 academic year. The data collection techniques used are observation, interview and questionnaire. The development model used in this research is the ADDIE model (Analysis-Design-Develop-Implement-Evaluate). The flow of this ADDIE development model can be seen in Figure 1.

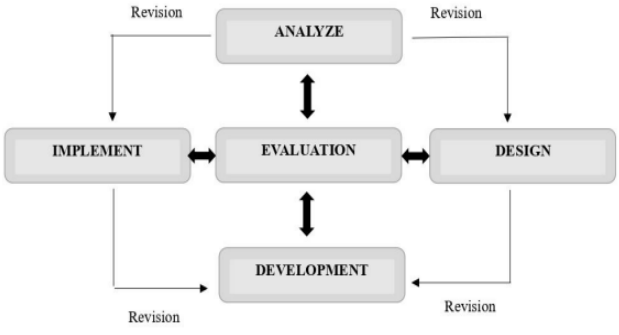

Figure 1. ADDIE Model Development (Darmansyah, 2023)

The development stages in this article is described as follows :

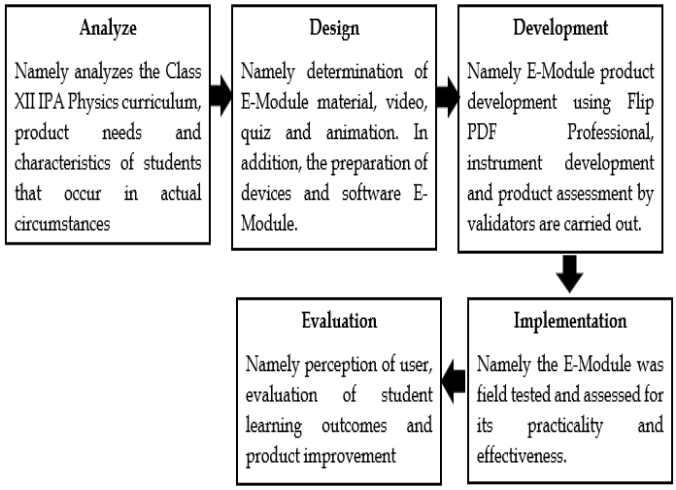

Figure 2. Development Stages

The validity analysis uses a Likert scale based on the validation sheet. The validity score was given using the Formula 1 :

$$P = \frac{Number\ of\ scores\ for\ each\ criterion\ selected}{Total\ ideal\ score}\ X\ 100\% \quad (1)$$

Description :
P : Validator percentage gain

The criteria for the level of achievement of the validity test by experts in the development of E-Modules listed in table 1 :

Table 1. Achievement Level of E-Module Validity

Achievement Level (%)	Qualifcation
81-100	Very feasible
61-80	Feasible
41-60	Feasible enough
21-40	Less feasible
≤ 20	Not feasible

(Syafril, 2019)

Practicality analysis uses a Likert scale based on the practicality sheet. Practicality scores were given using the Formula 2 :

$$P = \frac{Number\ of\ scores\ for\ each\ criterion\ selected}{Total\ ideal\ score}\ X\ 100\% \quad (2)$$

Description :
P : User percentage gain

The criteria for the level of achievement of the validity test by experts in the development of E-Modules listed in table 2 :

Table 2. Achievement Level of E-Module Practicality

Achievement Level (%)	Qualification
81-100	Very practical
61-80	Practical
41-60	Practical enough
21-40	Less practical
≤ 20	Not practical

(Syafril, 2019)

The E-Module effectiveness test was analyzed using normal gain to determine the improvement that occurred in the pre test and post test after being given treatment using the Formula 3:

$$g = \frac{Post\ test\ score - Pre\ test\ score}{Maximal\ score - Pre\ test\ score} \quad (3)$$

Description :
g : gain

The results obtained are categorized according to Table 3:

Table 3. Normalized Gain Category

Value (g)	Classification
g <0.30	Low
0.70 > g ≥ 0.30	Medium
g > 0.70	High

(Syafril, 2019)

The interpretation of the N-gain category in the form of percent (%) listed in Table 4:

Table 4. Normalized Gain Effectiveness Interpretation Category

N-Gain Percentage (%)	Interpretation
<40	Ineffective
40-55	Less effective
56-75	Effective enough
>76	Effective

(Syafril, 2019)

Result and Discussion

Results

This research was conducted based on the development stages of the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The results of the research conducted are described as follows:

Analyze

At this stage, curriculum or material analysis, learner characteristics analysis and product needs analysis are carried out. The analysis of the curriculum or material on Physics subjects developed into E-Modules as shown in Table 5.

Table 5. Learning Materials and Objectives

Material	Indicators of achievement of learning objectives
Concept basic Electric current Direct	Students can understand the concepts of electric charge, current, resistance, and potential difference, and demonstrate the relationship between resistivity, cross-sectional area, conductor length, and temperature to resistance with the PhET Simulation.
Ohm law	Students can state Ohm's law, explain its application in daily life, solve related problems, analyze the relationship between current, resistance, and voltage in circuits, and demonstrate experiments using PhET Simulation.
Kirchoff's Laws and Electrical Energy	Students can state Kirchhoff's laws I and II, explain their application in daily life, solve related problems, calculate power, energy, and electricity tariffs, and design an energy-efficient house.
Direct current electrical circuit analysis	Students can explain the properties of series and parallel circuits, calculate and analyze their applications in daily life, and design a DC electrical circuit with resistors and light bulbs using PhET Simulation.

Analysis of learner characteristics are general characteristics and specific characteristics. The general characteristics are number of students and physical condition of students. Specific characteristics are the learning styles and learning motivation of students. The product needs analysis listed in Table 6:

Table 6. Need Analysis

Question	Reality	
	Yes	No
Do you have a mobile phone to access teaching materials or technology-based learning media?	88.30%	11.70%
Do you have a laptop to access teaching materials or technology-based learning media?	29.50%	70.50%
Have you ever studied using E-Module integrated with video, audio dan animation?	44.20%	55.80%

Question	Reality	
	Yes	No
Have you ever used learning media in the form of learning media in the form of virtual practicum (simulation) in Physics lessons?	3.00%	97.0%
Do you need additional teaching materials that suit your needs for self-study at home?	97.0%	3.00%

From the above statement, it can be concluded that the majority of students already have cellphones, then 91.20% of students have never used E-Modules, 97.10% of students have never used PhET Simulation and 94.10% of students need independent teaching materials. Therefore, E-Modules integrated with PhET Simulation are needed in Physics subjects.

Design

At this stage, the storyboard of the E-Module is designed. Designing the E Module includes the cover, layout and content. Cover and layout were designed using canva and E-Module content was designed using Microsoft Word.

Development

In this third stage, the E-Module development was carried out in accordance with the storyboard that had been previously determined. The appearance of the E-Module that has been developed based on suggestions by media experts and revisions made to the E-Module with the results can be seen in Figure 3.

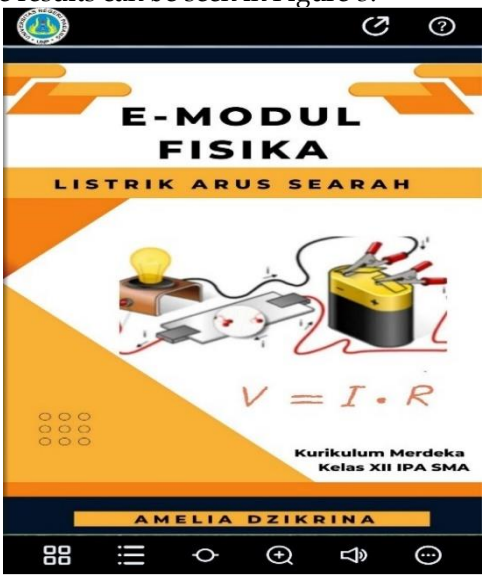

Figure 3. E-Module Development View

The E-Module will appear when the Next button is clicked by the user, either student or teacher, then the user can view and learn the contents of the E-Module. E-Module learning activity display is in the Figure 4.

Figure 4. E-Module Learning Activity

E-Module is validated by 3 experts, namely media, material and language experts. This statement is reinforced by research from Agung & Eliza (2021) stated that a valid E-Module is an E-Module that has been checked by experts so that the level of feasibility can be known.

The results of the E-Module validation in the fields of material, language and media can be seen in Table 7.

Table 7. E-Module Validation Results

Validation Type	Percentage	Category
Media Expert	93%	Very feasible
Material Expert	83%	Very feasible
Language Expert	89%	Very feasible
Average	88%	Very feasible

Referring to the validity criteria category, the results of the E-Module validity are included in the very feasible category. The results of the material, language and media validity analysis of the E-Module can be seen in Figure 5.

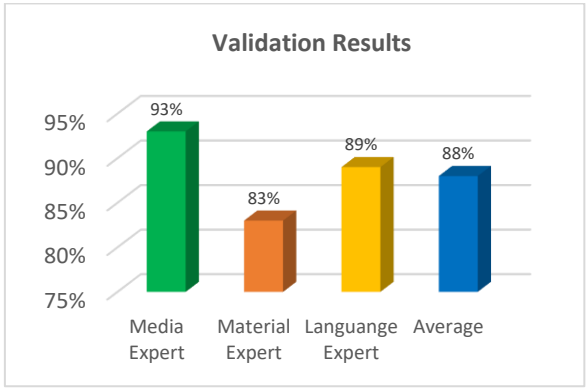

Figure 5. Validation Result Diagram

Implementation

In this section is the assessment of the E-Module in terms of practicality. The Practicality Test includes an assessment of teacher and student responses listed in Table 8.

Table 8. E-Module Practicality Results

Aspect	Teacher Percentage	Student Percentage	Category
Presentation	98%	96%	Very practical
Display	97%	96%	Very practical
Material	94%	96%	Very practical
Pedagogical effects	97%	96%	Very practical
Average	96%	96%	very practical

The results of the student and teacher practicality tests can be seen in Figure 6.

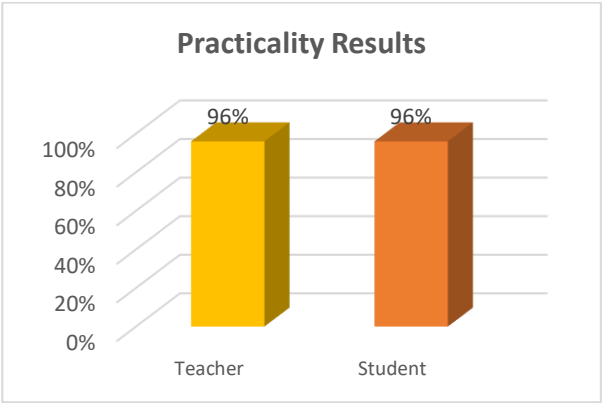

Figure 6. Diagram of Practicality Result

The results of practicality E-Module show that the average percentage is very practical category with a percentage of 96% from teacher dan students. The results of this study are reinforced by research from Putra et al. (2017) explaining that E-Modules have a practical category, by making interesting content so that students are motivated to learn.

The effectiveness of the E-Module was analyzed using one group pretest and postest techniques to students in the cognitive aspect seen from the pretest results obtained an average of 47.22 and at the time of the posttest increased to 87.50 and obtained Ngain score and Ngain percent can be seen in Table 9 :

Table 9. Psychomotor Aspect of Effectiveness Gain Value

	N	Min	Max	Mean	Std. Dv
Ngain score	36	0.33	1.00	0.81	0.20
Ngain percentage	36	33	100	81.39	20.48

Based on the Table 11, the N gain score is 0.81 (g>0.7) and is classified as high with the percentage of N gain is 81%, therefore it is categorized as effective. The results of this study are reinforced by research from Hidayati et al. (2020) E-Modules are considered effective in increasing learning outcomes of students of the UNP Educational Technology Curriculum department.

In the psychomotor aspect, it is seen from direct observation with four categories of psychomotor assessment according to Trowbridge and Bybe in (Herliani, 2009) is moving, manipulating, communicating and creating. Based on the observations, the average psychomotor score before using the E-Modul was 53.33 and increased after using the E-Modul to 88.33 and obtained the Ngain score and Ngain percent can be seen in Table 10 :

Table 10. Psychomotor Aspect of Effectiveness Gain Value

	N	Min	Max	Mean	Std. Dv
Ngain score	36	0.67	1.00	0.76	0.11
Ngain percentage	36	67	100	76.39	11.35

Based on the Table 12, the N gain score is 0.76 (g > 0.7) and is classified as high with the percentage of N gain is 76.39%, therefore it is categorized as effective. Therefore, the use of E-Modules can improve students cognitive and psychomotor learning outcomes. This is relevant to the research conducted by Masruroh & Agustina (2021) the use of E-Modules in learning activities can improve student learning outcomes. The learning outcomes in this study were indicated by the acquisition of an average posttest score higher than the average pretest score in both cognitive and psychomotor skills.

Evaluation

The purpose of the evaluate phase is to assess the quality of the instructional products and processes, both before and after implementation. At this evaluation stage, product quality can be determined through three aspects, namely 1) Perception, 2) Evaluation of student learning outcomes 3) Product improvement (Branch, 2009). Based on user perception, from the students point of view, it can be explained that E-Modules are very effective and useful in the learning process because E-Modules provide flexibility in learning, students also feel motivated to learn because E-Modules are presented in an interesting and (Hidayati, Bentri, et al., 2020)fun way, and the integration of PhET Simulation can help understand abstract Physics material. Meanwhile, from the teacher's side, the E-Module is considered very good to be used as independent teaching material for

students, because its components can be followed by students without direct instruction from the teacher. In addition, the integration with PhET Simulation is also considered to improve students' thinking skills and learning activeness. Therefore, this E-Module is considered a positive innovation in supporting learning, both in terms of students and teachers, and is expected to be applied more widely in the learning process.

The following is an analysis of student learning outcomes both cognitive and psychomotor aspects can be seen in Figure 7.

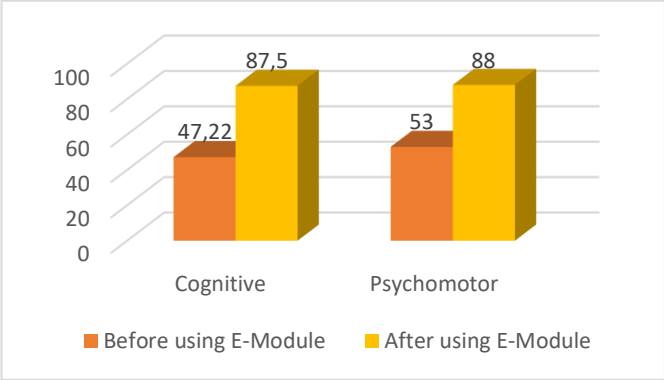

Figure 7. Improved Student Learning Outcomes

Based on the picture above, it can be concluded that student learning outcomes before using E-Modules are lower than after using E-Modules. Therefore, E-Modules can improve student learning outcomes in both cognitive and psychomotor aspects.

Discussion

The results of the E-Module development can activate students' senses because it integrates video and animation. The more senses used for learning, the easier it is for educators to convey information so that they can achieve the expected goals (Zahwa & Syafi'i, 2022). The virtual PhET Simulation practicum in the E-Module also makes it easier for students to understand abstract material. This statement is in line with the research of Armansyah et al. (2019) stated that visualization in learning can facilitate student understanding because it provides a visual representation of concepts that are difficult to understand. Simulations in E-Modules can also help develop process skills. This is in line with the theory of E. Dale, namely the cone of experience (Dale Cone of Experience) 1946 in Taibu et al. (2021) which states that people will usually remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they write or say and 90% of what they do. Therefore, the results showed that direct experience using PhET Simulation in the E-Module gives a deep impression of the information received so that it can improve process skills because students can explore and gain practical experience to prove the theoretical concepts that have been taught. The results also show that E-Modules can also increase students' learning independence. This is in line with the research of Hidayati, Bentri, et al. (2020) stated that media that integrates text, images, animations, and videos can be used independently by students because it provides flexibility in learning, allowing them to repeat the material according to their individual needs and speed.

Conclusion

Based on the results of research and discussion of the product development of e-modules integrated with PhET Simulation in learning Physics Class XII IPA, it can be concluded that the developed E-Module integrated PhET Simulation integrated are valid with a percentage of 88.30% was obtained with feasible criteria. E-Module integrated PhET Simulation on physics learning class XII IPA in high school developed is very practical with a percentage of 96% from teachers and 96% from students. E-Module integrated phet simulation on physics learning class XII IPA in high school developed is effective. The results of the data effectiveness test using one group pre test post test with a cognitive Ngain percentage of 81% and a psychomotor Ngain percentage of 76.39% means that there is a significant difference between before being treated with phet simulation integrated e-module after being treated.

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Author Contributions

Finding problems related to the availability of teaching materials, drafting research instruments, developing E-Modules integrated phet simulation, writing initial drafts, providing draft ideas, reviewing and editing, monitoring research progress and providing feedback on research. All authors contributed to the content and each part of this article. We have read and approved the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper

References

Agung, M., & Eliza, F. (2021). Validitas Modul Elektronik untuk Mata Kuliah Pengukuran dan Instrumen. *MSI Transaction on Education*, *2*(2), 78–84. https://doi.org/10.46574/mted.v2i2.55

Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open*, *10*(3). https://doi.org/10.1177/2158244020938702

Arisandy, D., Marzal, J., & Maison, M. (2021). Pengembangan Game Edukasi Menggunakan Software Construct 2 Berbantuan Phet Simulation Berorientasi pada Kemampuan Berpikir Kreatif Siswa. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(3), 3038–3052. https://doi.org/10.31004/cendekia.v5i3.993

Armansyah, F., Sulton, S., & Sulthoni, S. (2019). Multimedia Interaktif Sebagai Media Visualisasi Dasar-Dasar Animasi. *Jurnal Kajian Teknologi Pendidikan*, 224–229. https://doi.org/10.17977/um038v2i32019p224

Asih, T. L. B., Prayitno, B. A., & Ariani, S. R. D. (2022). Improving the Problem-Solving Skill of Students using Problem-Based Learning-Based E-Modules. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1447–1452. https://doi.org/10.29303/jppipa.v8i3.1696

Azhar, Manik, R. E., Nabila, R., Natuna, D. A., & Irawan, D. (2024). Critical Thinking Skills of Students Through Guided Discovery Learning Model Assisted by PhET Media on Stationary and Walking Wave. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 3548–3555. https://doi.org/10.29303/jppipa.v10i7.7212

Basit, M., & Suhartini, S. (2023). Module Discovery Learning Biodiversity Material Based on Gunungkidul Beach to Increasing Interest and Independence in Learning of High School Students. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 12116–12129. https://doi.org/10.29303/jppipa.v9i12.5159

Branch, R. M. (2009). *Instructional Design: The ADDIE Approad*. London: Springerb Science Business Media.

Darmansyah. (2023). *Model-Model Desain Instruksional*. Depok: Rajawali Press.

Dini, A., Rahmatan, H., Muhibbudin, Nurmaliah, C., & Safrida. (2023). Application of the E-module combined with the Guided Inquiry Learning Model to Increase Student Motivation and Learning Outcomes on the Structure and Function of Plant Tissues. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4768–4776. https://doi.org/10.29303/jppipa.v9i6.3857

Etanastia, D., Noviyana, H., & AB, J. S. (2022). Pengembangan Modul Elektronik Berbasis Pendekatan Kontekstual Pada Pokok Bahasan Bangun Ruang Sisi Datar. *JURNAL E-DuMath*, *8*(1), 8–14. https://doi.org/10.52657/je.v8i1.1640

Hakim, L., Lubis, P. H. M., Lefudin, L., & Sulistyowati, R. (2022). The Relationship between Learning Style toward Mastery of Concepts and Problem Solving Skill Introduction to Nuclear Physics for Pre-Service Teacher. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 666–673. https://doi.org/10.29303/jppipa.v8i2.1176

Herayanti, L., Habibi, H., & Sukroyanti, B. A. (2022). Development of Inquiry-Based Teaching Materials to Improve Physics Teacher's Conseptual Understanding. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 3110–3116. https://doi.org/10.29303/jppipa.v8i6.2543

Herliani, E. (2009). *Penilaian Hasil Belajar untuk Guru SMP*. Bandung: PPPTK IPA

Hidayati, A., Bentri, A., Yeni, F., Zuwirna, & Eldarni. (2020). The Development of Instructional Multimedia based on Science, Environment, Technology, and Society (SETS). *Journal of Physics: Conference Series*, *1594*(1). https://doi.org/10.1088/1742-6596/1594/1/012016

Hidayati, A., Saputra, A., & Efendi, R. (2020). Pengembangan E-Modul Berorientasi Strategi Flipped Classroom pada Pembelajaran Jaringan Komputer. *Jurnal Resti (Rekayasa Sistem Dan Teknologi Informasi)*, *4*(3), 429–437. https://doi.org/https://doi.org/10.29207

Imaniah, E., Susilawati, S., Sutrio, S., & Kosim, K. (2023). Effect of the PhET Assisted Problem Based Learning Model on Student Learning Outcomes in Wave Material. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4731–4737. https://doi.org/10.29303/jppipa.v9i6.3836

Khotimah, H., Supena, A., & Hidayat, N. (2019). Meningkatkan attensi belajar siswa kelas awal melalui media visual. *Jurnal Pendidikan Anak*, *8*(1), 17–28. https://doi.org/10.21831/jpa.v8i1.22657

Maksum, H., & Purwanto, W. (2022). The Development of Electronic Teaching Module for Implementation of Project-Based Learning during the Pandemic. *International Journal of Education in Mathematics, Science and Technology*, *10*(2), 293–307. https://doi.org/10.46328/ijemst.2247

Malkawi, E., Bawaneh, A. K., & Bawa'aneh, M. S. (2021). Campus off, education on: Uaeu students' satisfaction and attitudes towards e-learning and virtual classes during covid-19 pandemic. *Contemporary Educational Technology*, *13*(1), 1–14. https://doi.org/10.30935/cedtech/8708

Masruroh, D., & Agustina, Y. (2021). E-modul berbasis Android sebagai pendukung pembelajaran daring dan upaya untuk meningkatkan hasil belajar peserta didik. *Jurnal Ekonomi, Bisnis Dan Pendidikan*, *1*(6), 559–568. https://doi.org/10.17977/um066v1i62021p559-568

Miranda, J., Navarrete, C., Noguez, J., Molina-Espinosa, J. M., Ramírez-Montoya, M. S., Navarro-Tuch, S. A., Bustamante-Bello, M. R., Rosas-Fernández, J. B., & Molina, A. (2021). The core components of education 4.0 in higher education: Three case studies in engineering education. *Computers and Electrical Engineering*, *93*(February). https://doi.org/10.1016/j.compeleceng.2021.107278

Nabilah, R. S., & Jumadi, J. (2022). Study of Content Analysis : Trends of Educational Research for Physics Courses in Indonesia. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 393–400. https://doi.org/10.29303/jppipa.v8i1.1293

Naimanova, D., Lebedeva, L., Akpayeva, A., Astambayeva, Z., Ryabova, E., & Yessenova, K. (2023). *Investigation of Primary School Teachers Student-Centered Teaching and Technology Integration Competencies*. 1–23. https://doi.org/https://doi.org/10.46328/ijemst.3681

Nurdini, S. D., Husniyah, R. H., Chusni, M. M., & Mulyana, E. M. (2022). Penggunaan Physics Education Technology (PhET) dengan Model Inkuiri Terbimbing untuk Meningkatkan Hasil Belajar Siswa pada Materi Fluida Dinamis. *Jurnal Ilmiah Pendidikan Fisika*, *6*(1), 136. https://doi.org/10.20527/jipf.v6i1.4412

Nurhidayati, A., Putro, S. C., & Widiyaningtyas, T. (2018). Penerapan Model Pbl Berbantuan E-Modul Berbasis Flipbook Dibandingkan Berbantuan Bahan Ajar Cetak Pengaruhnya Terhadap Hasil Belajar Pemrograman Siswa Smk. *Teknologi Dan Kejuruan: Jurnal Teknologi, Kejuruan, Dan Pengajarannya*, *41*(2), 130–138. https://doi.org/10.17977/um031v41i22018p130

Parker, R., Thomsen, B. S., & Berry, A. (2022). Learning Through Play at School – A Framework for Policy and Practice. *Frontiers in Education*, *7*(February), 1–12. https://doi.org/10.3389/feduc.2022.751801

Permadi, A., & Novrianti, N. (2023). Pengembangan E-Modul Mata Kuliah Fotografi Departemen Kurikulum dan Teknologi Pendidikan FIP UNP. *Jurnal Family Education*, *3*(1), 48–54. https://doi.org/10.24036/jfe.v3i1.79

Purba, M. C., & Sujatmiko, B. (2023). Pengembangan E-Modul Interaktif Berbasis Website Dengan Model Pembelajaran Project Based Learning Untuk Meningkatkan Minat Belajar Siswa Pada Mata Pelajaran Pkwu Di Smkn 10 Surabaya. *IT-Edu : Jurnal Information Technology and Education*, *8*(1), 147–156. https://doi.org/10.26740/it-edu.v8i1.55850

Putra, K. W. B., Wirawan, I. M. A., & Pradnyana, G. A. (2017). Pengembangan E-Modul Berbasis Model Pembelajaran Discovery Learning Pada Mata Pelajaran "Sistem Komputer" Untuk Siswa Kelas X Multimedia Smk Negeri 3 Singaraja. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *14*(1), 40–49. https://doi.org/10.23887/jptk.v14i1.9880

Sabaruddin, S., Hafni, F., & Fitriyawany, F. (2023). Development of a Discovery Learning E-Module Assisted By Phet Simulation for Sound Wave Material. *JURNAL ILMIAH DIDAKTIKA: Media Ilmiah Pendidikan Dan Pengajaran*, *23*(2), 176. https://doi.org/10.22373/jid.v23i2.22121

Saputra, H., & Mustika, D. (2022). Analysis the Conceptual Understanding Level and Understanding Model of Pre-Service Physics Teacher. *Jurnal Penelitian Pendidikan IPA*, *8*(5), 2367–2372. https://doi.org/10.29303/jppipa.v8i5.2246

Saputri, R., Wilujeng, I., Jumadi, J., Nurohman, S., & Purnama, A. Y. (2023). Development of PBL Modul-El to Improve Problem Solving Students of Physics Education Program. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8376–8382. https://doi.org/10.29303/jppipa.v9i10.4092

Sugiyono. (2014). *Metode Penelitian Kuantitatif*, *Kualitatif dan R&D*. Bandung: Alfabeta.

Susanti, E., Septiana, S., Meilinda, S., & Rosa, I. M. (2023). Effectiveness of Using Google Sites-Based E-Modules to Optimize Critical Thinking Skills: Student Perceptions Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 10555–10561. https://doi.org/10.29303/jppipa.v9i12.5887

Susilawati, S., Doyan, A., Mulyadi, L., Abo, C. P., & Pineda, C. I. S. (2022). The Effectiveness of Modern Physics Learning Tools Using the PhET Virtual Media Assisted Inquiry Model in Improving Cognitive Learning Outcomes, Science Process Skills, and Scientific Creativity of Prospective Teacher Students. *Jurnal Penelitian Pendidikan IPA*, *8*(1), 291–295. https://doi.org/10.29303/jppipa.v8i1.1304

Syafril. (2019). *Statistik Pendidikan*. Jakarta: Prenadamedia Group.

Taibu, R., Mataka, L., & Shekoyan, V. (2021). Using PhET simulations to improve scientific skills and attitudes of community college students. *International Journal of Education in Mathematics, Science and Technology*, *9*(3), 353–370.

https://doi.org/10.46328/IJEMST.1214

Tarman, B. (2020). Editorial: Reflecting in the shade of pandemic. *Research in Social Sciences and Technology*, *5*(2), i–iv. https://doi.org/10.46303/ressat.05.02.ed

Tatli, Z., GÜLAY, A., MURADOĞLU, B., & BEKAR, Ş. N. (2023). Evaluation of digital instructional materials developed by primary school teacher candidates with different learning styles. *Journal of Educational Technology and Online Learning*, *6*(3), 578–601. https://doi.org/10.31681/jetol.1222327

Ula, E. M., Paidi, P., & Jumadi, J. (2023). Electronic Module Development Science-Based Learning Flipbook Theory System Breathing in Humans for Student Class VIII SMP/MTs. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1593–1599. https://doi.org/10.29303/jppipa.v9i4.1755

Yayang, E. (2019). Pengembangan E-Modul Berbasis Web Dengan Menggunakan Aplikasi Moodle Pada Mata Kuliah Pengelolaan Perpustakaan. *Edutech*, *18*(1), 25. https://doi.org/10.17509/e.v18i1.14113

Yeni, F., Eldarni, & Rahmi, U. (2019). The Validation of Digital Learning Materials Using Edmodo for Elementary School. *Advances in Social Science, Education and Humanities Research, Volume 372*, *372*(ICoET), 4–7.

Yevira, R., Yustina, & Yennita. (2023). Development of SETS (Science Environment Technology and Society) Based E-Modules on Environmental Pollution Materials to Increase Learning Interest and Critical Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6306–6313. https://doi.org/10.29303/jppipa.v9i8.4229

Zahwa, F. A., & Syafi'i, I. (2022). Pemilihan Pengembangan Media Pembelajaran Berbasis Teknologi Informasi. *Equilibrium: Jurnal Penelitian Pendidikan Dan Ekonomi*, *19*(01), 61–78. https://doi.org/10.25134/equi.v19i01.3963