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The creation of flipbook-based electronic teaching modules using the Heyzine website on Static Electricity Material for Class XII Students

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E-Module, Heyzine, Statistic Electricity, Kurikulum Merdeka.

Abstract
This research aims to develop physics teaching materials based on electronic teaching modules on static electricity in class. This research uses a research and development method (Research & Development) which refers to the 4D Model with 4 stages including the definition stage, design stage, development stage and deployment stage. The result of this research is an electronic teaching module which is expected to make it easier for teachers in the learning process and attract students' interest in independent learning.

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INTRODUCTION

Education is defined as a lifelong learning experience in all environments and situations that have a positive impact on the growth of each individual. Education has the capacity to shape an individual's character in a positive way, allowing them to apply their knowledge in everyday life. Through education, an individual can cultivate positive behaviors and characteristics, setting an example for others. Education plays a significant role in the growth of a country, as it contributes to the development of a qualified workforce. Consequently, learning activities in the classroom must be executed to the greatest extent possible to achieve the expected objectives (Annisa, 2022).

In the contemporary educational landscape, learning activities in the classroom must evolve to keep pace with the rapid advancements in science and technology. As Marryono Jamun (2018) notes, the latest development in this field is the term "cyber teaching," which refers to a learning process facilitated by the internet. Another term that has gained significant popularity is e-learning, which refers to a learning model that utilizes Communication and Information

Technology media, particularly the Internet. E-learning can also be understood as learning supported by technology, such as electronic devices capable of displaying images, audio, and video.

Within Phase F, which corresponds to the XII SMA curriculum, static electricity emerges as a pivotal subject. It encompasses the principles of electrostatics, electric charge, electric field, and Coulomb force, highlighting its relevance in everyday life. However, the educational experience is often hindered by various factors, as reported by Preliana (2015). A notable challenge is the inadequate comprehension of the subject matter by students, a problem that stems from multiple sources. This is caused by several factors, including:

1) Static electricity material is abstract material and difficult for students to understand.
2) Teachers often use monotonous learning methods, so students become bored and sleepy.
3) The teaching materials used are less interesting.

The Heyzine website is one website that can be used to develop electronic teaching modules to make them more visually appealing. Research conducted by Ismail et al. (2023) has identified several advantages of the Heyzine application, including:

1) It can be used to create interactive and interesting electronic teaching modules.
2) It can produce electronic teaching modules with a variety of outputs.
3) Facilitates seamless sharing of electronic teaching modules with students.

The utilization of this teaching module is expected to facilitate the learning process for teachers and to encourage students to engage in independent learning.

METHOD

This research employs a Research and Development (R&D) approach, defined as a method of developing and evaluating learning programs, processes, and learning products. The outcome of this product development is a flipbook-based electronic teaching module.

The following section delineates the research stages:

1. Preparation Stage

During this stage, researchers define development requirements, also known as development needs analysis. To design this module, supporting hardware specifications are required. However, the designer is not required to use the specifications described below; alternative specifications, whether lower or higher, are permissible.In designing this electronic module using the following hardware specifications:

1) AMD Ryzen 3-4300U processor
2) Screen resolution 14″ FHD (1920 x 1080) IPS
3) 8GB DDR4-3200MHz RAM

2. Design Stage

At this stage, the researcher designs the layout and content of the teaching module to be compiled. The process begins with finding an independent curriculum teaching module template, designing material, making cover designs, looking for images and videos supporting learning, and preparing LKPD. The following software is used to support module development:

1) Microsoft Word application
2) Canva/Canva Web application
3) Youtube application
4) Google site: *Google Scholar, Google Drive, dan Google Chrome.*
5) PhET-Simulator
6) Website Heyzine

3. Completion Stage

Subsequent to the design process, the results of the teaching module are converted into PDF format and uploaded to the Heyzine website. This process produces an electronic teaching module that is then reviewed by experts for validation.

4. Deploy Stage

E-modules that have been customized to students' learning needs are uploaded to the platform and shared with research participants. Testing was conducted by administering a pre-test to measure students' initial understanding and a post-test after they accessed the e-module, to assess the extent to which their understanding improved. In addition, a survey was also conducted to obtain feedback from students and teachers regarding the ease of use and effectiveness of the materials presented.

Analysis of test results and user feedback is used to evaluate the success of the e-module in improving student understanding. If some shortcomings or aspects need improvement, for example, material that is too complex or an unintuitive interface design, remedial steps are taken to improve the module's effectiveness. This evaluation process is essential in ensuring that the e-module can be an effective and engaging learning tool for students. (Clark & Mayer, 2016).

RESULTS AND DISCUSSION

1. e-Module Design Results

The present study produces flipbook-based electronic teaching module products on static electricity material for class XII SMA. The teaching module component consists of the author's identity, general description, five-point learner profile, target learners, instructions for using the module, prerequisite competencies, infrastructure, learning objectives, learning steps, material, and reflection, which is the core part of a teaching module. The following are details of each component produced:

1) Module cover page: The cover page display is a module cover designed based on the material contained in it.

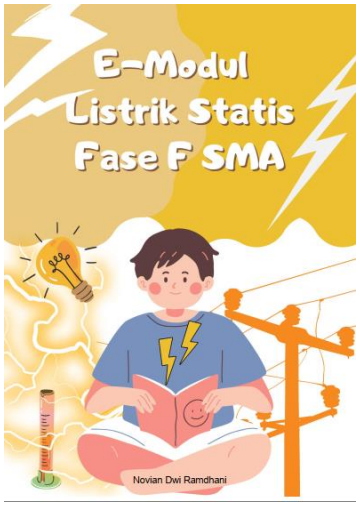


Figure 1. Cover Module

2) Table of contents display: This display contains details of the parts that will appear in the teaching module.

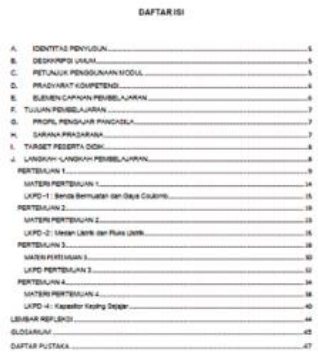
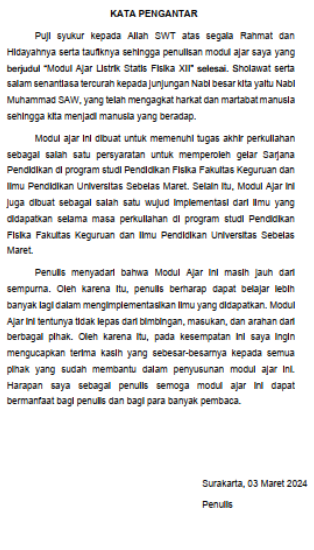


Figure 2. Tabel of Content Display

3) Display of preface: This display contains the writing of the author of

the preface section for the module that has been developed.



KATA PENGANTAR

Puji syukur kepada Allah SWT atas segala Rahmat dan Hidayahnya serta taufiknya sehingga penulisan modul ajar saya yang berjudul "Modul Ajar Listrik Statis Fisika XII" selesai. Sholawat serta salam senantiasa tercurah kepada junjungan Nabi besar kita yaitu Nabi Muhammad SAW, yang telah mengangkat harkat dan martabat manusia sehingga kita menjadi manusia yang beradap.

Modul ajar ini dibuat untuk memenuhi tugas akhir perkuliahan sebagai salah satu persyaratan untuk memperoleh gelar Sarjana Pendidikan di program studi Pendidikan Fisika Fakultas Keguruan dan Ilmu Pendidikan Universitas Sebelas Maret. Selain itu, Modul Ajar ini juga dibuat sebagai salah satu wujud implementasi dari ilmu yang didapatkan selama masa perkuliahan di program studi Pendidikan Fisika Fakultas Keguruan dan Ilmu Pendidikan Universitas Sebelas Maret.

Penulis menyadari bahwa Modul Ajar ini masih jauh dari sempurna. Oleh karena itu, penulis berharap dapat belajar lebih banyak lagi dalam mengimplementasikan ilmu yang didapatkan. Modul Ajar ini tentunya tidak lepas dari bimbingan, masukan, dan arahan dari berbagai pihak. Oleh karena itu, pada kesempatan ini saya ingin mengucapkan terima kasih yang sebesar-besarnya kepada semua pihak yang sudah membantu dalam penyusunan modul ajar ini. Harapan saya sebagai penulis semoga modul ajar ini dapat bermanfaat bagi penulis dan bagi para banyak pembaca.

Surakarta, 03 Maret 2024

Penulis

Figure 3. Display of Preface

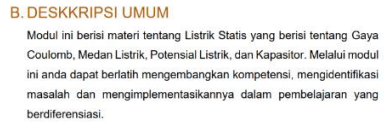
4) Display of author identity and module identity: This section displays the identity of the module author and the identity of the module that has been developed.

A. IDENTITAS PENYUSUN

Nama Penyusun	: Novian Dwi Ramdhani
Institusi	: UNS
Tahun	: 2024
Jenjang Sekolah	: SMA
Mata Pelajaran	: Fisika
Fase/Kelas/Semester	: F/XII/1
Alokasi Waktu	: 12 JP (12 x 45 menit)

Figure 4. Display of Author Identity

5) Display of module description: This section displays a brief description of the content contained in the module that has been developed.

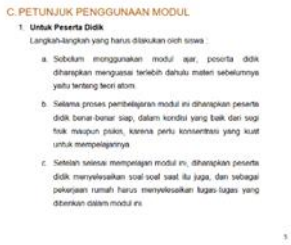


B. DESKKRIPSI UMUM

Modul ini berisi materi tentang Listrik Statis yang berisi tentang Gaya Coulomb, Medan Listrik, Potensial Listrik, dan Kapasitor. Melalui modul ini anda dapat berlatih mengembangkan kompetensi, mengidentifikasi masalah dan mengimplementasikannya dalam pembelajaran yang berdiferensiasi.

Figure 5. Display of Description

6) Display of instructions for using the moduleThis display presents the instructions and usage of the module shown for students and for teachers.



C. PETUNJUK PENGGUNAAN MODUL

1. **Untuk Peserta Didik**

Langkah-langkah yang harus dilakukan oleh siswa :

a. Sebelum menggunakan modul ajar, peserta didik diharapkan menguasai terlebih dahulu materi sebelumnya yaitu tentang teori atom.

b. Selama proses pembelajaran modul ini diharapkan peserta didik benar-benar siap, dalam kondisi yang baik dari segi fisik maupun psikis, karena perlu konsentrasi yang kuat untuk mempelajarinya.

c. Setelah selesai mempelajari modul ini, diharapkan peserta didik menyelesaikan soal-soal saat itu juga, dan sebagai pekerjaan rumah harus menyelesaikan tugas-tugas yang diberikan dalam modul ini.

Figure 6. Display of Instruction

7) Display of prerequisite competencies: In this section, the prerequisite competencies that must be met by students before carrying out learning using this teaching module are displayed.

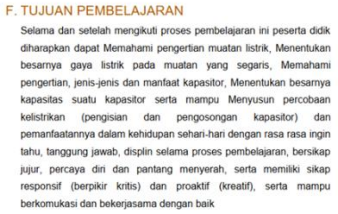
D. PRASYARAT KOMPETENSI

Modul ajar ini ditujukan untuk siswa SMA Fase F kelas XII. Sebelum mempelajari modul ajar ini siswa diharapkan menguasai terlebih dahulu materi Pada Fase D, yaitu peserta didik telah mempelajari teori atom, atau minimalnya mengingatkan lagi di awal pembelajaran. Dengan demikian siswa diharapkan memperoleh pengalaman belajar yang sistematis dan siap mempelajari modul ini.

Figure 7. Display of Prerequisite Competencies

8) Display of learning objectives: In this section, the learning objectives that will be achieved by the author

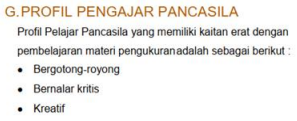
in the preparation of this teaching module are displayed.


F. TUJUAN PEMBELAJARAN

Selama dan setelah mengikuti proses pembelajaran ini peserta didik diharapkan dapat Memahami pengertian muatan listrik, Menentukan besarnya gaya listrik pada muatan yang segaris, Memahami pengertian, jenis-jenis dan manfaat kapasitor, Menentukan besarnya kapasitas suatu kapasitor serta mampu Menyusun percobaan kelistrikan (pengisian dan pengosongan kapasitor) dan pemanfaatannya dalam kehidupan sehari-hari dengan rasa rasa ingin tahu, tanggung jawab, displin selama proses pembelajaran, bersikap jujur, percaya diri dan pantang menyerah, serta memiliki sikap responsif (berpikir kritis) dan proaktif (kreatif), serta mampu berkomukasi dan bekerjasama dengan baik

Figure 8. Display of Learning Objective

9) Display of Pancasila Teacher Profile: In this section, the Pancasila Teacher Profile selected by the author is displayed to be used in the developed teaching module.

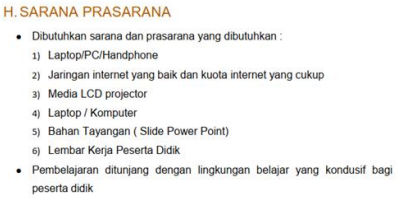

G. PROFIL PENGAJAR PANCASILA

Profil Pelajar Pancasila yang memiliki kaitan erat dengan pembelajaran materi pengukuran adalah sebagai berikut :

- Bergotong-royong
- Bernalar kritis
- Kreatif

Figure 9. Display of Pancasila Profile

10) Presentation of Facilities and Infrastructure: In this section, the infrastructure is written in the form of tools and materials needed to carry out the learning according to what is arranged in this teaching module.


H. SARANA PRASARANA

- Dibutuhkan sarana dan prasarana yang dibutuhkan :
  1) Laptop/PC/Handphone
  2) Jaringan internet yang baik dan kuota internet yang cukup
  3) Media LCD projector
  4) Laptop / Komputer
  5) Bahan Tayangan (Slide Power Point)
  6) Lembar Kerja Peserta Didik
- Pembelajaran ditunjang dengan lingkungan belajar yang kondusif bagi peserta didik

Figure 10. Display of Facilities and Infrastructure

11) Presentation of target learners: In this section, the target learners that the author wants to reach through the learning module developed by the author are presented.


I. TARGET PESERTA DIDIK

Perangkat ajar ini dirancang untuk :

√	Peserta didik regular/tipikal
	Peserta didik dengan kesulitan belajar
	Peserta didik berpencapaian tinggi
	Peserta didik dengan ketunaan

Figure 11. Display of Target Learner

12) Display of learning steps: This section shows how to follow up the initial assessment created in this module.


J. LANGKAH -LANGKAH PEMBELAJARAN

Alokasi Waktu: 12 JP (12 x 45 menit)

Proses Pembelajaran:

1. Pertemuan I : Hukum Coulomb: Gaya antar partikel
2. Pertemuan II : Medan Listrik dan Fluks Listrik
3. Pertemuan III : Potensial Listrik dan Energi Potensial Listrik
4. Pertemuan IV : Kapasitor

Figure 12. Display of Learning Step

13) Learning implementation plan display: This display shows the Learning Implementation Plan (RPP) section that will be used in learning according to what is compiled in this module.

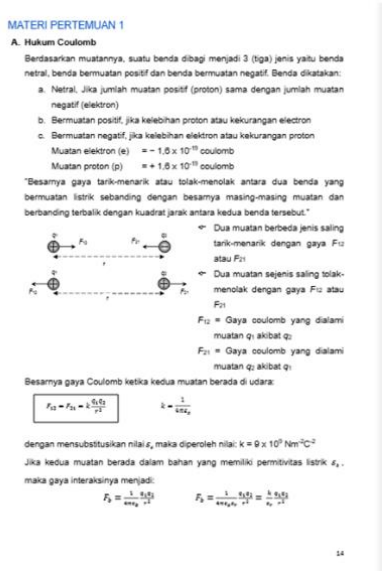
PERTEMUAN 1

Materi : Pendahuluan Listrik Statis dan Hukum Coulomb

Aktivitas Guru	Aktivitas Peserta Didik	Alokasi Waktu
Pembukaan		
• Guru menyapa sambil memeriksa kehadiran peserta didik • Guru meminta salah satu peserta didik untuk memimpin doa sebelum pembelajaran dimulai	• Peserta didik berdoa sebelum pembelajaran dimulai	5 menit
Pendahuluan tentang Hukum Coulomb		
• Guru menampilkan gambar atau video fenomena listrik statis dalam kehidupan sehari-hari :	• Peserta didik mengamati gambar atau video yang ditampilkan oleh guru • Peserta didik menebak apa yang sebenarnya terjadi dengan gambar tersebut dan kaitannya dengan materi yang akan diajarkan .	5 menit
• Guru meminta peserta didik untuk menyampaikan gagasan dari fenomena yang mereka lihat .	• Peserta didik mengungkapkan gagasan terkait fenomena yang mereka lihat.	5 menit
Pertanyaan pemantik : Kita sudah mengetahi feneomena-fenomena yang berkaitan dengan listrik statis, mengapa hal tersebut bisa terjadi?		
Kegiatan Inti		

Figure 13. Display of Learning Implementation Plan

14) Material Display: This section displays a summary of the material presented in the module. This material summary is divided into 4 sessions.



MATERI PERTEMUAN 1

A. Hukum Coulomb

Berdasarkan muatannya, suatu benda dibagi menjadi 3 (tiga) jenis yaitu benda netral, benda bermuatan positif dan benda bermuatan negatif. Benda dikatakan:

a. Netral, Jika jumlah muatan positif (proton) sama dengan jumlah muatan negatif (elektron)
b. Bermuatan positif, jika kelebihan proton atau kekurangan electron
c. Bermuatan negatif, jika kelebihan elektron atau kekurangan proton

Muatan elektron (e) = − 1,6 x 10^{-19} coulomb
Muatan proton (p) = + 1,6 x 10^{-19} coulomb

"Besarnya gaya tarik-menarik atau tolak-menolak antara dua benda yang bermuatan listrik sebanding dengan besarnya masing-masing muatan dan berbanding terbalik dengan kuadrat jarak antara kedua benda tersebut."

Dua muatan berbeda jenis saling tarik-menarik dengan gaya F_{12} atau F_{21}

Dua muatan sejenis saling tolak-menolak dengan gaya F_{12} atau F_{21}

F_{12} = Gaya coulomb yang dialami muatan q_1 akibat q_2

F_{21} = Gaya coulomb yang dialami muatan q_2 akibat q_1

Besarnya gaya Coulomb ketika kedua muatan berada di udara:

$F_{12} = F_{21} = k\frac{q_1 q_2}{r^2}$ $k = \frac{1}{4\pi\varepsilon_0}$

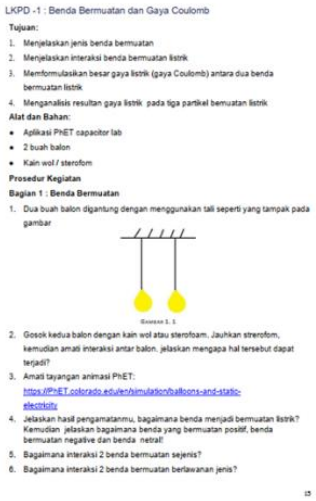
dengan mensubstitusikan nilai ε_0 maka diperoleh nilai: k = 9 x 10^9 $Nm^{-2}C^{-2}$

Jika kedua muatan berada dalam bahan yang memiliki permitivitas listrik ε_0 , maka gaya interaksinya menjadi:

$F_k = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$ $F_k = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1 q_2}{r^2} = \frac{1}{\varepsilon_r}\frac{q_1 q_2}{r^2}$

Figure 14. Display of Material

15) LKPD Display: This section displays the Learner Worksheet or LKPD created by the author and applied to 4 sessions.



LKPD -1 : Benda Bermuatan dan Gaya Coulomb

Tujuan:

1. Menjelaskan jenis benda bermuatan
2. Menjelaskan interaksi benda bermuatan listrik
3. Memformulasikan besar gaya listrik (gaya Coulomb) antara dua benda bermuatan listrik
4. Menganalisis resultan gaya listrik pada tiga partikel bermuatan listrik

Alat dan Bahan:

- Aplikasi PhET capacitor lab
- 2 buah balon
- Kain wol / sterofom

Prosedur Kegiatan

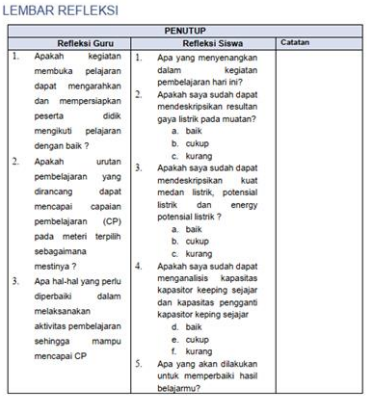
Bagian 1 : Benda Bermuatan

1. Dua buah balon digantung dengan menggunakan tali seperti yang tampak pada gambar

2. Gosok kedua balon dengan kain wol atau sterofoam. Jauhkan sterofom, kemudian amati interaksi antar balon. jelaskan mengapa hal tersebut dapat terjadi?
3. Amati tayangan animasi PhET: https://PhET.colorado.edu/en/simulation/balloons-and-static-electricity
4. Jelaskan hasil pengamatanmu, bagaimana benda menjadi bermuatan listrik? Kemudian jelaskan bagaimana benda yang bermuatan positif, benda bermuatan negative dan benda netral!
5. Bagaimana interaksi 2 benda bermuatan sejenis?
6. Bagaimana interaksi 2 benda bermuatan berlawanan jenis?

Figure 15. Display of LKPD

16) Tutor and learner reflections display: In this section reflections are written and displayed to students and teachers after going through the learning compiled in this module.



LEMBAR REFLEKSI

PENUTUP		
Refleksi Guru	**Refleksi Siswa**	**Catatan**
1. Apakah kegiatan membuka pelajaran dapat mengarahkan dan mempersiapkan peserta didik mengikuti pelajaran dengan baik ? 2. Apakah urutan pembelajaran yang dirancang dapat mencapai capaian pembelajaran (CP) pada meteri terpilih sebagaimana mestinya ? 3. Apa hal-hal yang perlu diperbaiki dalam melaksanakan aktivitas pembelajaran sehingga mampu mencapai CP	1. Apa yang menyenangkan dalam kegiatan pembelajaran hari ini? 2. Apakah saya sudah dapat mendeskripsikan resultan gaya listrik pada muatan? a. baik b. cukup c. kurang 3. Apakah saya sudah dapat mendeskripsikan kuat medan listrik, potensial listrik dan energy potensial listrik ? a. baik b. cukup c. kurang 4. Apakah saya sudah dapat menganalisis kapasitas kapasitor keping sejajar dan kapasitas pengganti kapasitor keping sejajar d. baik e. cukup f. kurang 5. Apa yang akan dilakukan untuk memperbaiki hasil belajarmu?	

Figure 16. Display of Tutor and Learner Reflections

17) Glossary Display: This section displays key words in the learning arranged in this module

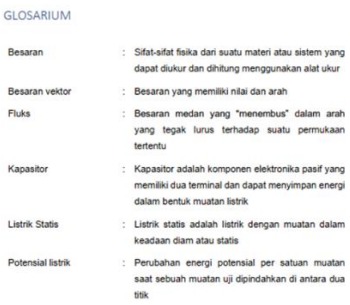


Figure 17. Display of Glossary

2. Effectiveness Evaluation

a. Expert Validation

The module underwent a validation process involving three subject-matter experts in physics education and two instructional designers. The experts assessed the module based on four key criteria: 1) Content accuracy – ensuring that the concepts presented align with scientific principles. 2) Pedagogical effectiveness – evaluating how well the module facilitates learning. 3) Interactivity and engagement – assessing the multimedia integration and user experience. 4) Technical usability – verifying ease of navigation and overall functionality.

The expert panel provided an average validation score of 4.5 out of 5, indicating high quality across all evaluation metrics. They particularly highlighted the module's interactive approach and well-structured content layout as key strengths.

b. Student and Teacher Feedback

The tested learning module showed high student engagement, with 85% of students reporting an improvement over conventional methods. These findings align with the Self-Determination theory (Ryan & Deci, 2000), which states that interactive and contextual material can increase students' intrinsic motivation through autonomy, competence, and relatedness. This level of engagement may be triggered by multimodal approaches in the module, such as dynamic visualization and interactive simulations that stimulate learning interest. In addition, 78% of students reported increased conceptual understanding, especially on electric field interactions and Coulomb's law. This indicates that the module successfully overcomes the challenge of abstraction in static physics with a real-phenomenon-based approach, as emphasized in the constructivist learning framework (Bransford et al., 2000). Focusing

on contextualizing concepts through applicative examples may help students build more accurate mental models, reducing common misconceptions such as the difference between electric fields and electric forces.

From a practical perspective, 90% of teachers consider the module easy to integrate with face-to-face teaching. The organized module structure and intuitive interface allow for adaptation without technical barriers, according to user-centered design principles (Norman, 2013). Ease of navigation is also supported by cognitive load theory (Sweller, 2011), which states that the structured presentation of information reduces cognitive load, allowing students to focus on essential concepts. The combination of survey methods and group discussions in collecting feedback strengthens the validity of the findings, as recommended in mixed-methods research (Creswell & Clark, 2017). However, further studies need to address the limitations of the sample (only 50 students and five teachers) and potential response bias (self-report). The implication is that this module has the potential to become an effective companion tool if developed on a broader scale and with longitudinal evaluation to measure long-term impact.

3. Challenges and Limitations

Limitations of Accessibility Although e-modules offer various benefits for students, there are challenges related to accessibility. About 20% of students have difficulty accessing modules due to unstable internet connections, a significant obstacle to online learning. This demonstrates the need to develop an offline version of the module to ensure all students can access the material, even when the internet is unavailable. Research by Spector (2014) shows that limited access to technology, especially internet connection, can affect the effectiveness of technology-based learning. By providing alternative access, such as an offline version, it is hoped that all students can overcome these problems and access content more easily without being limited by technical factors in their environment.

Technology Adaptation and Small-Scale Implementation Another challenge is the technical adaptation some teachers require to integrate e-modules into their learning plans. Some teachers need a short training session to make the most of the

modules. This highlights the importance of providing appropriate professional training so that teachers can utilize technology in their teaching. Moreover, this research was only conducted in three schools, so the results cannot be generalized to a broader population. As noted by Clark (2012), the successful implementation of educational technology requires special attention to the readiness and training of teachers. Therefore, it is necessary to conduct a broader trial to assess the impact of the module more comprehensively.

4. Future Research Directions

A longitudinal study is needed to evaluate long-term knowledge retention to strengthen the validity of the module's impact. Research by Bjork (2011) on spaced repetition shows that repeating material at certain time intervals improves memory consolidation, so long-term studies can measure the module's effectiveness in facilitating continuous learning. In addition, expanding the sample to various school environments will enrich the generalization of findings, given that socio-economic factors and technological infrastructure influence the adoption of digital tools (Cohen, 2013). Sample diversity also helps to identify variations in pedagogical needs, ensuring that modules can be adapted inclusively in different contexts.

Comparing digital platforms such as Heyzine with other tools (e.g., Moodle or Kahoot) can reveal the specific advantages of modules in increasing interactivity. According to Alpert and Bitzer (1970), the effectiveness of a learning platform depends on the suitability of the design to cognitive objectives. A comparative analysis based on multimedia learning theory (Mayer, 2009) can also evaluate the optimization of the combination of text, visuals, and simulations. Thus, this recommendation can potentially increase the relevance and equality of access to science education in the digital era.

CONCLUSION

This study successfully developed a flipbook-based interactive e-module using the Heyzine platform for static electricity learning in grade XII, which was proven to increase student engagement and independent learning through multimedia integration. The module's validation showed a high quality of content and

usability, supported by positive feedback from students and teachers and a significant improvement in conceptual understanding, as reflected in the comparison of pre-test and post-test results. However, limitations of the study, such as the small scale of implementation and dependence on internet access, indicate the need to expand the scope of research to various school contexts and to develop offline options to reach areas with limited infrastructure. In the future, comparative studies with other digital platforms (such as Moodle or Nearpod) are needed to evaluate the specific advantages of the Heyzine module in terms of interactivity and pedagogical effectiveness. These findings have strategic implications for the world of education, especially in supporting the implementation of the Merdeka Curriculum through improving digital literacy and the blended learning approach. Training teachers to develop interactive e-modules is the key to maximizing the potential of technology in learning, and integrating digital materials with classroom activities can create a holistic learning experience. Thus, this e-module not only answers the challenge of abstraction in physics but also paves the way for the transformation of science education to be more inclusive, adaptive, and oriented toward the needs of students in the digital era.

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