



## **Development of Alternating Current and Voltage E-Book Based on Blender Software to Improve Students Critical Abilities in Senior High School**

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**Abstract:** This study aims to: (1) produce a physics e-book based on blender software that is suitable for use in schools, (2) determine the practicality of a physics e-book based on blender software for teachers and students of class XII MIPA in the learning process, (3) determine the effectiveness of a physics e-book based on blender software to improve critical thinking skills. This study uses the ADDIE model. In the analysis stage, researchers conducted observations, interviews, and distributed questionnaires to teachers and students of class XII MIPA SMAN 2 Sabang; the design stage designed the e-book grid, animation of alternating current and voltage based on blender software, compiled teaching modules, and test instruments; the development stage obtained the results of the e-book draft, teaching modules, data analysis techniques used in the development stage, namely V'Aiken and feasibility. The implementation stage used a pretest-posttest control group design. The evaluate stage tested the data generated. The results showed that: (1) the e-book based on the assessment of expert lecturers, teachers and colleagues is very feasible to be used in physics learning based on the results of the assessment of media feasibility and material feasibility, obtaining an average score of 94.55% and 92.37% with a very feasible category; (2) The e-book is very practical to use based on the practicality response questionnaire of teachers and students which obtained an average score of 97.67% and 92.48% with a very practical category; (3) The e-book is effective in improving critical thinking skills in the experimental class with a gain of 0.6.

**Keywords:** blender software, critical thinking skills, e-book on alternating current and voltage

## **Pengembangan E-Book Arus dan Tegangan Bolak-balik Berbasis Software Blender untuk Meningkatkan Kemampuan Kritis Siswa Sekolah Menengah Atas**

**Abstrak:** Penelitian ini bertujuan: (1) menghasilkan e-book fisika berbasis software blender yang layak digunakan di sekolah, (2) mengetahui kepraktisan e-book fisika berbasis software blender bagi guru dan siswa kelas XII MIPA dalam proses pembelajaran, (3) mengetahui keefektifan e-book fisika berbasis software blender untuk meningkatkan kemampuan berpikir kritis. Penelitian ini menggunakan model ADDIE. Pada tahap analisis, peneliti melakukan observasi, wawancara, dan menyebarkan angket kepada guru dan siswa kelas XII MIPA SMAN 2 Sabang; tahap *design* merancang kisi-kisi e-book, animasi arus dan tegangan bolak-balik berbasis software blender, menyusun modul ajar, dan instrumen soal; tahap *development* memperoleh hasil draft e-book, modul ajar, teknik analisis data yang digunakan dalam tahap *development* yaitu V'Aiken dan kelayakan. Tahap implementasi menggunakan desain *pretest-posttest control group design*. Tahap *evaluate* menguji data yang dihasilkan. Hasil penelitian menunjukkan bahwa: (1) produk e-book berdasarkan penilaian dosen ahli, guru dan teman sejawat sangat layak digunakan dalam pembelajaran fisika berdasarkan hasil penilaian kelayakan media dan kelayakan materi memperoleh skor rata-rata 94,55% dan 92,37% dengan kategori sangat layak; (2) Produk e-book sangat praktis digunakan berdasarkan angket respon kepraktisan guru dan siswa yang memperoleh skor rata-rata 97,67% dan 92,48% dengan kategori sangat praktis; (3) Produk e-book yang dikembangkan efektif dalam meningkatkan kemampuan berpikir kritis pada kelas eksperimen dengan hasil n-gain 0,6.

**Kata kunci:** arus dan tegangan listrik bolak-balik, berpikir kritis, e-book, software blender

## INTRODUCTION

In the 21st century, many technologies have been developed, especially technology in the field of education. Education is the main focus in the industrial revolution 4.0 and the current era of super smart society (society 5.0). The transformation from the transition from Industrial Revolution 4.0 to 5.0 has brought substantial changes to the field of education. In the 4.0 era, education began to utilize technology such as online learning and artificial intelligence to increase efficiency and access to learning. Teachers and students are required to understand digital technology in order to adapt to the fully automated and connected learning ecosystem. Demands on the quality of teachers shift to the ability to master technology (Akihary et al., 2023). Education in the 21st century, in addition to requiring teachers to master technology, also requires students to have the ability to learn and be able to innovate (Nirmala et al., 2021). Entering the 5.0 era, the focus of education is not only on the use of technology, but also on strengthening human values, empathy, and creativity (Wijaya et al., 2024). Technology is no longer just a tool, but becomes a collaborative partner in shaping the character and critical thinking skills of students (Susilawati et al., 2020). Learning skills needed in 21st-century education include the ability to manage one's own thoughts (metacognition), communicate effectively, think critically and creatively, be able to solve problems independently, be able to collaborate with others, be able to create innovation, and understand and apply literacy creatively in various contexts (Indarta et al., 2022). The importance of having 21st-century skills is because the use of technology can improve learning outcomes and the quality of education (Cárdenas-Sainz et al., 2023). Through education, teachers and students will be able to gain all of these skills to create superior human resources.

In reality, in the 21st century, there are still several schools that have inadequate facilities for students and educators to develop soft skills and life skills. This is in accordance with Trirahma's research (2023) that physics learning only uses printed books without any other supporting learning media, monotonous learning makes students less interested in learning physics, abstract physics material makes students experience difficulties in learning (Novalia et al., 2023). This is also in accordance with the research of astuti (Astuti et al., 2023) that current physics learning still uses monotonous media and approaches, learning methods that only focus on educators lecturing, resulting in students feeling bored in learning physics and students' critical thinking skills not developing. This condition shows that limited facilities and less innovative learning approaches are obstacles in creating an effective and meaningful learning atmosphere for students (Dahlan et al., 2023). Based on the results of observations conducted by researchers on July 25-27, 2024 at SMAN 1 Sabang and SMAN 2 Sabang through interviews, distributing learning media needs analysis questionnaires and material difficulty questionnaires to teachers and students, researchers found that students felt that the existing physics learning was boring because they only learned from printed books without any practicums, short learning times and abstract physics material also made students have difficulty in understanding the learning. Students stated that if physics learning was presented with animation in learning, it would greatly help them in learning and understanding the material given by the teacher. In addition, students had difficulty in understanding the learning also because there were no practicums after learning. According to the information obtained from teacher interviews at SMA 1 Sabang, researchers found that practicums were not carried out because laboratory facilities were inadequate. The existing practicum tools could no longer be used because they were damaged and some were missing. The teacher also stated that although the practicum was never done in the laboratory, to take the students' skill scores

the teacher made a simple practicum tool that could be used to take the students' skill scores, but this simple practicum tool certainly did not make the students understand the entire material presented. The results of the interview with the research teacher found that the students' scores were still below the KKM. The teacher stated that students tended to only be able to do the same practice questions as the example questions, if the practice questions given were different from the example questions, students would have difficulty in representing the correct physics formula to do the practice questions. The results of the brainstorming with the teacher showed that the teacher agreed that if physics learning was added with supporting animations in the material it would make learning more interesting.

To overcome this, students certainly need to be facilitated with appropriate facilities and infrastructure. Teachers can facilitate teaching materials that can trigger students' thinking skills. One of the teaching materials that is appropriate and suitable for facilitating students based on observation results is e-books because it is in accordance with the development of education in the 21st century (Nirmala et al., 2021). E-books can be accessed using smartphones and are also more efficient in their use. The use of e-books via smartphones will also have a positive impact on students' thinking skills, one of which is on high-level thinking skills or better known as High Order Thinking Skill (HOTS) (Linda et al., 2021), will improve creative thinking skills, Critical thinking (Ardiyanti & Nuroso, 2021). The imbalance between the demands of education in the 21st century and the reality in schools, requires teaching materials that can improve students' thinking skills. Teaching materials that can be used to improve students' thinking skills are e-books. According to (Gee, 2003) the use of e-books in learning will motivate students to be more active and the cognitive aspect of students' thinking skills will be more honed (Ardiyanti & Nuroso, 2021), In addition, physics e-books equipped with 3D animated videos can help students understand physics learning at school or at home.

Improving critical thinking skills we can use appropriate teaching materials so that they can attract students' attention to think critically skills can be further improved. Based on the results of observations from both schools and the existing problems, the researcher chose to develop electronic teaching materials, namely physics e-books which contain animated videos that will help students in learning (Ardiyanti & Nuroso, 2021). Based on the development of this e-book, students not only listen to the teacher's explanation, but can also see abstract physics concepts in the form of animation (Putri & Friska, 2024). Based on previous research and the problems that researchers found when conducting observations, it encouraged researchers to conduct "Development of Physics E-Books on Alternating Current and Voltage Learning Materials Utilizing Blender Software to Enhance Critical Thinking Skills of Students in Senior High School".

## **METHOD**

This study uses the type of research and development. Research and Development is a research method that produces certain products in its development and must be tested using a validation sheet to assess the feasibility and effectiveness of the resulting product (Partono et al., 2021). In this study, the product to be produced is a physics e-Book on the material of alternating current and voltage using blender software as an application to develop the product. The resulting product can later be used to improve critical thinking skills and mathematical representation of students. in this study is a development model that adapts the design from Branch. The research model developed by Branch consists of 5 stages, namely: (1) Analyze, (2) Design, (3) Development, (4) Implement, (5) Evaluate).

Data collection methods include observation, questionnaires, empirical tests, and large-scale tests. Observation is used to obtain information about field conditions and the initial

stages of obtaining data. The questionnaire is in the form of a questionnaire to validate the instrument, feasibility, and practicality of the Blender Software-Based E-Book.

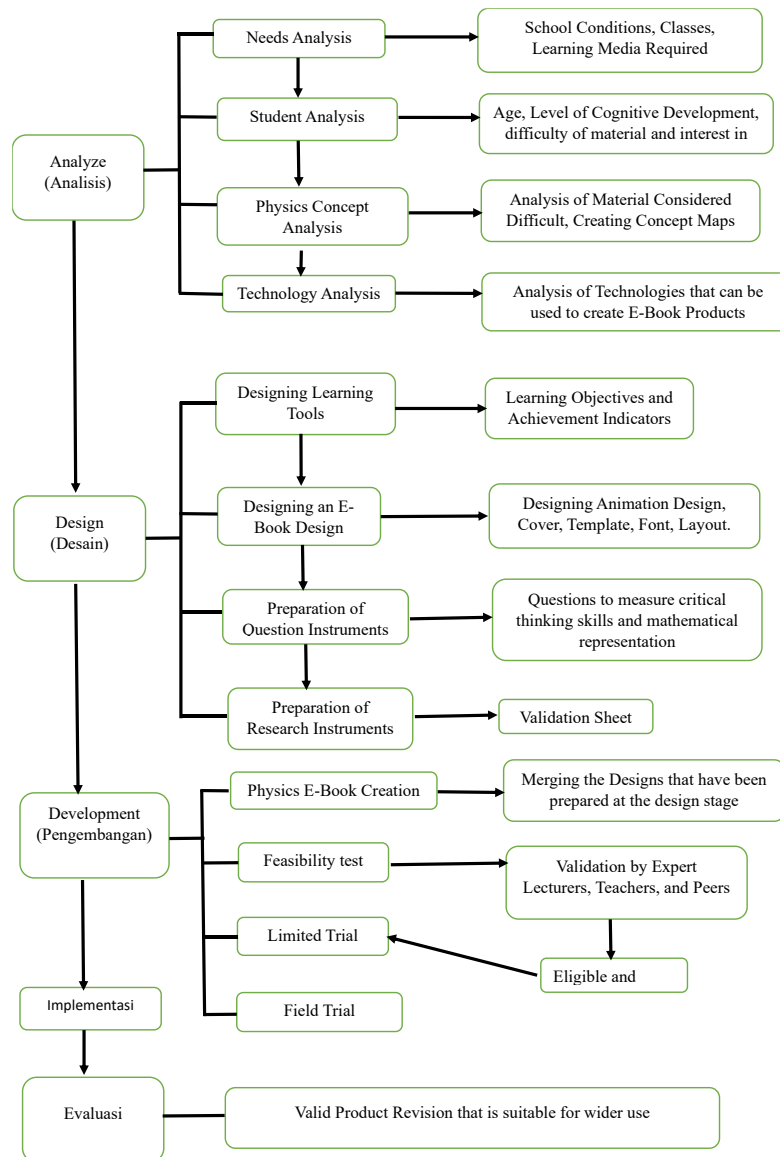


Figure 1. Research Stages

The data analysis of the product assessment instrument validation was conducted using the Aiken's V formula, by calculating the content validity coefficient based on evaluations from  $n$  experts, we can calculate the V index.

$$V = \frac{\sum s}{n(c-1)} \quad (1)$$

description:

$s$  :  $r-l_o$

$l_o$  : Lowest Validity Assessment Score

$c$  : Highest Validity Assessment Score

$r$  : Score given by an assessor

$n$  : Number of respondents

$V$  : Expert agreement index regarding item validity

**Table 1.** Aiken's Validity Criteria

Skor	Kategori
$V < 0.4$	Low validity
$0.4 \leq V < 0.8$	Medium validity
$0.8 \leq V \leq 1.0$	High validity

Evaluation of the validation results regarding the feasibility of the Blender Software-Based E-book on Alternating Current and Electric Voltage.

$$N_m = A \times B \times C \quad (2)$$

description:

A : number of validators

B : maximum validation score (5)

C : number of validation criteria items.

The percentage value of feasibility %K is obtained using the equation below:

$$\%K = \left( \frac{N}{N_m} \right) \times 100\% \quad (3)$$

description :

N : total score obtained

**Table 2.** Conversion of Media and Material Eligibility Criteria Scores

Percentage of Achievement (%)	Interpretasi
$81 \leq \text{Skor} \leq 100$	Very Eligible
$61 \leq \text{Skor} \leq 80$	Eligible
$41 \leq \text{Skor} \leq 60$	Quite Eligible
$21 \leq \text{Skor} \leq 40$	Less Eligible
$0 \leq \text{Skor} \leq 20$	Very Uneligible

Analysis of Critical Thinking and Mathematical Representation Ability Improvement using standard gain.

$$\text{Standar gain (g)} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{maximum score} - \text{pretest score}} \quad (4)$$

**Table 3.** Criteria N-Gain Score

Score (g)	Criteria
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Medium
$g < 0.3$	Low

## RESULTS AND DISCUSSION

### Analysis Stage

In this analysis stage, the researcher conducted observations at SMAN 1 Sabang and SMAN 2 Sabang. The information obtained by the researcher was conducted by conducting observations on the learning process, interviews with subject teachers,

interviews with students, and distributing questionnaires on learning media needs.

### Design Stage

In the design stage, the results of the analysis stage were summarized by the researcher and a design was made for the development of an e-book on alternating current and voltage based on blender software. The initial design of this design stage was the creation of a flowchart, storyboard, collection of relevant materials and animations that would be used and developed in the form of a grid that functions as a reference in compiling e-book content.

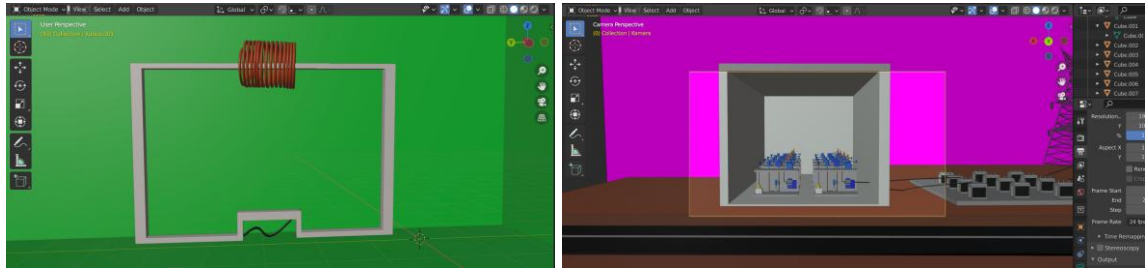


Figure 2. Animation of Alternating Current and Voltage

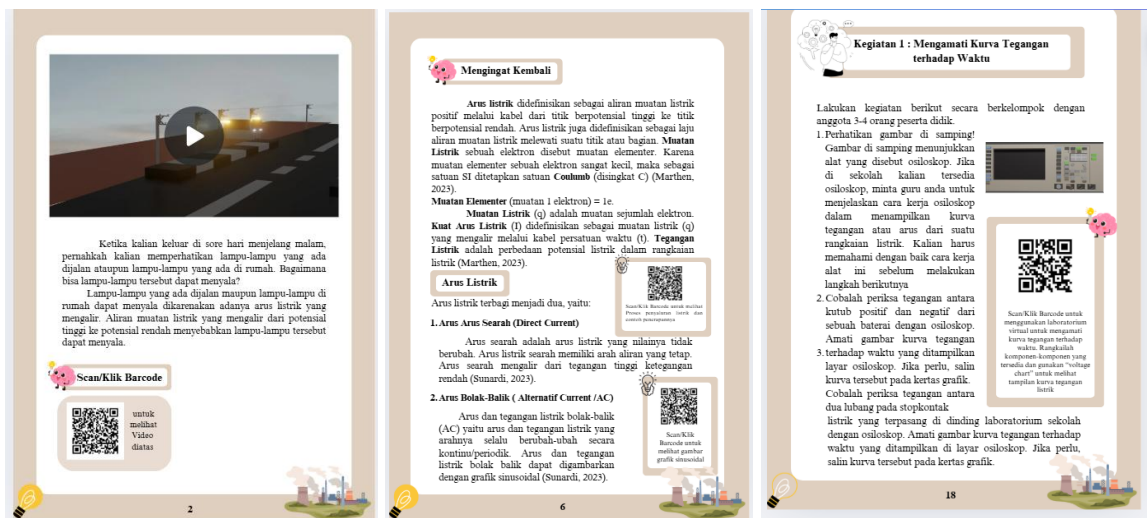


Figure 3. Draft of Alternating Current and Voltage E-Book Based on Blender Software

### Development Stage

At the development stage, it is done by starting to render the blender software animation that has been completed at the design stage so that it can be used and saved in mp4 format. At this stage, the development of the alternating current and voltage e-book based on blender software, test instruments, teaching modules, media and material expert validation sheets, and validating the products and instruments that have been developed before being used and distributed widely. After validation is carried out and the validation results are obtained in the form of valid and reliable products, instruments and teaching modules, field testing may be carried out.

1. Results of making an E-book on alternating current and voltage based on Blender software

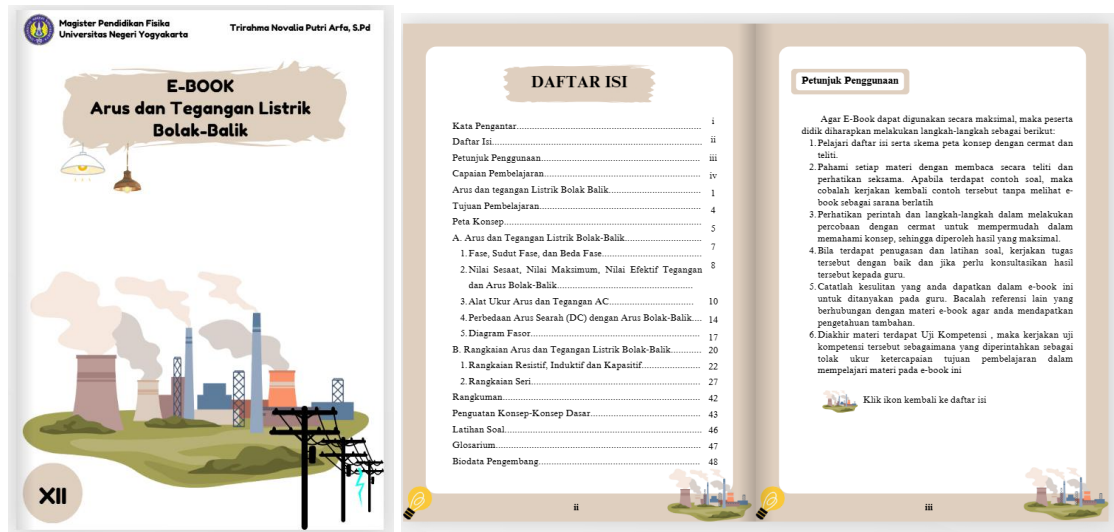


Figure 4. E-Book Product Alternating Current and Voltage Electricity Based on Blender Software

2. Results of Feasibility of E-Book Alternating Current and Voltage Electricity Expert Validation Media

The results of the recapitulation of the media feasibility assessment from media experts, teachers, and colleagues on the components of the product appearance and product programming aspects obtained the results of the validity of the e-book media which can be seen in Table 4.

Table 4. Results of E-Book Media Validity by Media Experts

Component	Average Score (%)	Category
View	92,85	Very Worthy
Programming	96,25	Very Worthy
Total Average Score	94,55	Very Worthy

3. Results of the Feasibility of the E-Book on Alternating Current and Voltage of Electricity Validated by Material Experts

The summarized results of evaluations from material experts, teachers, and peers regarding the components of content feasibility, presentation quality, and language and communication aspects indicate the validity level of the e-book material, as presented in

Table 5. Validity of E-Book Material by Material Experts

Components assessed	Average Score (%)	Category
Content Feasibility	93,54	Very Eligible
Presentation Feasibility	92,5	Very Eligible
Language and Communication	91,07	Very Eligible
Average Total Score	92,37	Very Eligible

Based on the table of the results of the assessment of e-book materials by experts, teachers and colleagues, the aspect of content feasibility got a validity score of 93.54% with a very feasible category, the aspect of presentation feasibility got a validity score of

92.5% with a very feasible category, and the aspect of language and communication got a score of 91.07% with a very feasible category. So that the average score for material feasibility got a score of 92.37% with a very feasible category

### Implementation Stage

This implementation was carried out with two stages of trials, namely limited trials and extensive trials. Limited trials used a practicality questionnaire and one group pretest-posttest from 30 students of class XII MIPA 1 at MAN 1 West Aceh, while large-scale trials used a pretest-posttest control group design consisting of three classes, namely 1 class as an experiment, and 2 contrast classes.

#### 1. Practical Results by Teachers

The practical results of the e-book on alternating current and voltage based on Blender software by teachers (practitioners) can be seen in Table 6.

**Table 6.** Practical Results of the E-book on Alternating Current and Voltage Based on Blender Software by teachers

Aspects	Score (%)	Category
E-Book Appearance	96,19	Very practical
Material Presentation	97,77	Very practical
Language	98,33	Very practical
Media Operation	97,77	Very practical
Media Benefits	98,33	Very practical
Average Score of Aspects	97,67	Very practical

Based on the table, it can be seen that the results of the practicality of the e-book on alternating current and voltage based on blender software in terms of the e-book display aspect got a practicality score of 96.19% with a very practical category, the material presentation aspect got a score of 97.77% with a very practical category, the linguistic aspect got a score of 98.33% with a very practical category, the media operation aspect 97.77% with a very practical category, and the media benefits aspect got a score of 97.67% with a very practical category. So that the average value of the practicality of the e-book by the teacher got a score of 97.67% and was included in the very practical category.

#### 2. Results of Practicality by Students

The results of the practicality of the e-book on alternating current and voltage based on blender software by students can be seen in Table 7.

**Table 7.** Results of the Practicality of the E-book on Alternating Current and Voltage Based on Blender Software by Students

Aspects	Score (%)	Category
E-Book Appearance	92,38	Very practical
Material Presentation	91,33	Very practical
Language	92,83	Very practical
Media Operation	91,55	Very practical
Media Benefits	94,33	Very practical
Average Score of Aspects	92,48	Very practical

Referring to the table, it is evident that the results of the practicality of the e-book on alternating current and voltage based on blender software by students consist of 5 aspects, namely the e-book display aspect gets a score of 92.38% with a very practical practicality category, the material presentation aspect gets a score of 91.33% with a very practical category, the linguistic aspect gets a score of 92.83% with a very practical category, the media operation aspect gets a score of 91.55% with a very practical category, and the media benefits aspect gets a score of 94.33% with a very practical category. Based on these five aspects, the average value is 92.48% and is included in the very practical category.

### 3. Critical Thinking N-Gain Test

**Table 8.** Critical Thinking N-Gains

<b>N-gain Critical Thinking</b>	
<b>Class</b>	<b>Mean N-Gain Critical Thinking</b>
Experiment	0.60
Contrast 1	0.20
Contrast 2	0.23

Based on the table above, the average N-Gain value for critical thinking skills is obtained, for the average N-Gain value of the experimental class, it gets a score of 0.60, which is included in the medium N-Gain value criteria, which means that learning in the experimental class using E-books is quite effective in improving critical thinking skills. In contrast 1 and contrast 2 classes, the average N-Gain critical thinking scores are 0.20 and 0.23 with low N-Gain value criteria, which means that learning that only uses printed books and powerpoint slides in contrast 1 class and printed books in contrast 2 class is less effective in improving critical thinking skills.

### Evaluation

The E-book on alternating current and voltage based on blender software gets a score of 97.67% and 92.48%, which is included in the very practical category according to teachers and students. These results are supported by research conducted by Upe' (Ashshidiqqi, 2017). Stating that learning devices with the discovery learning model developed in the study are very practical in improving students' critical thinking skills with an average practicality value of 92.7% with a very practical category. Based on limited and large-scale tests analyzed based on the N-Gain value and statistical tests, an increase in pretest to posttest results was found. In the limited trial class, the average N-gain value was 0.33 for critical thinking skills and N-gain for the experimental class using the e-book on alternating current and voltage got an average N-gain score of 0.60 for critical thinking.

These results are in line with research conducted by (Rahman, 2021), learning using a multi-representation approach with learning videos has been shown to improve students' critical thinking skills based on the N-Gain results of 0.62 which is included in the moderate category. Previous studies indicate that innovative learning media play a crucial role in improving students' thinking skills by enabling flexible, interactive, and inquiry-oriented learning experiences (Yusuf & Widyaningsih, 2017). Research conducted by Upe' (2022), stated that the learning device with the discovery learning model developed in the study was quite effective with the effectiveness value of the learning device based on the N-gain value of 0.69, which means that the value is categorized as moderate, which means that the learning device developed is quite effective in improving students' critical thinking skills.

## CONCLUSION

Based on the results of the development and research, it can be concluded: the e-book product of alternating current and voltage based on blender software developed based on the assessment of expert lecturers, teachers and colleagues on the material and media aspects is very feasible to be used in physics learning. This is based on the results of the assessment of the appropriateness of the media and the feasibility of the material which obtained an average score of 94.55% and 92.37% with a very feasible category. The e-book product of alternating current and voltage based on blender software developed is very considered practical according to the responses from the practicality questionnaire of teachers and students. This is based on the results of the practicality of teachers and students who obtained an average score of 97.67% and 92.48% with a very practical category. The e-book product of alternating current and voltage based on blender software developed effectively improves critical thinking skills in the experimental class with a value of N-gain 0,69

## BIBLIOGRAPHY

- Akihary, W., Maruanaya, R. F., Lestuny, C., & Maruanaya, S. P. (2023). The YouTube-Assisted Discovery Learning Model: Improving Students' Cognitive Learning Outcomes and Critical Thinking. *Journal of Education and Learning*, 17(4), 548–554. <https://doi.org/10.11591/edulearn.v17i4.20851>
- Ardiyanti, F., & Nuroso, H. (2021). Abstract : Analysis of the Level Critical Thinking Skills of Class XI MIPA in. *Karst : Jurnal Pendidikan Fisika dan Terapannya*, 4, 21–26. <https://doi.org/10.46918/karst.v4i1>
- Ashshidiqqi, H. (2017). *Pengembangan E-book Multimedia Interaktif Berbasis Flash pada Konsep Kingdom Animalia*. <https://repository.uinjkt.ac.id/dspace/handle/123456789/34285>
- Astuti, D., Susanto, R., Cahyono, D., & Astuti, M. T. (2023). The Effect of Problem Based Learning Work Sheet Usage on Student Learning Outcomes. *MUDIR (Jurnal Manajemen Pendidikan)*, 5(2), 404–408. <https://doi.org/10.55352/mudir.v5i2.594>
- Cárdenas-Sainz, B. A., Barrón-Estrada, M. L., Zatarain-Cabada, R., & Chavez-Echeagaray, M. E. (2023). Evaluation of Extended Reality (XR) Technology on Motivation for Learning Physics Among Students in Mexican Schools. *Computers & Education: X Reality*, 3(July), 100036. <https://doi.org/10.1016/j.cexr.2023.100036>
- Dahlan, M. M., Abdul Halim, N. S., Kamarudin, N. S., & Zuraine Ahmad, F. S. (2023). Exploring Interactive Video Learning: Techniques, Applications, and Pedagogical Insights. *International Journal of Advanced and Applied Sciences*, 10(12), 220–230. <https://doi.org/10.21833/ijaas.2023.12.024>
- Gee, J. P. (2003). What Video Games Have to Teach Us About Learning and Literacy. *Computers in Entertainment*, 1(1), 20. <https://doi.org/10.1145/950566.950595>
- Indarta, Y., Jalinus, N., Waskito, W., Samala, A. D., Riyanda, A. R., & Adi, N. H. (2022). Relevansi Kurikulum Merdeka Belajar dengan Model Pembelajaran Abad 21 dalam Perkembangan Era Society 5.0. *Edukatif: Jurnal Ilmu Pendidikan*, 4(2), 3011–3024. <https://doi.org/10.31004/edukatif.v4i2.2589>
- Linda, R., Zulfarina, Z., Mas'ud, M., & Putra, T. P. (2021). Peningkatan Kemandirian dan Hasil Belajar Peserta Didik Melalui Implementasi E-Modul Interaktif IPA Terpadu Tipe Connected Pada Materi Energi SMP/MTs. *Jurnal Pendidikan Sains Indonesia*, 9(2), 191–200. <https://doi.org/10.24815/jpsi.v9i2.19012>

- Nirmala, M. F. T., Gebze, D. A., Tumanggor, A. M. R., Lengkong, M., & Wilujeng, I. (2021). Physics Learning with E-Book Using Problem Based Learning (PBL) Model to Improve Image Representation Ability of High School Students on Optical Material. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)*, 528(Icriems 2020), 547–554. <https://doi.org/10.2991/assehr.k.210305.080>
- Novalia, T., Arfa, P., & Jannah, M. (2023). Development of Video Learning Based on Blender Software in High School. *Jurnal Geuthèè: Penelitian Multidisiplin (Multidisciplinary Research)*, 6(2), 147–157. <https://doi.org/10.52626/jg.v>
- Partono, P., Wardhani, H. N., Setyowati, N. I., Tsalitsa, A., & Putri, S. N. (2021). Strategi Meningkatkan Kompetensi 4C (Critical Thinking, Creativity, Communication, & Collaborative). *Jurnal Penelitian Ilmu Pendidikan*, 14(1), 41–52. <https://doi.org/10.21831/jpipfip.v14i1.35810>
- Putri, I. W., & Friska, J. (2024). *Development of Interactive E-Book by Flip PDF Professional Application for the Improvement of Students' Competence in French Language*. 8(March), 31–38. <https://doi.org/10.52403/gijash.20240105>
- Rahman, S. (2021). Pentingnya Motivasi Belajar dalam Meningkatkan Hasil Belajar. *Merdeka Belajar, November*, 289–302. <https://doi.org/10.56916/ejip.v4i2.1265>
- Susilawati, E., Agustinasari, A., Samsudin, A., & Siahaan, P. (2020). Analisis Tingkat Keterampilan Berpikir Kritis Siswa SMA. *Jurnal Pendidikan Fisika Dan Teknologi*, 6(1), 11–16. <https://doi.org/10.29303/jpft.v6i1.1453>
- Wijaya, M. A. H., Risdianto, E., & Koto, I. (2024). Development of a Digital Module for Kinematics Material Based on 3D Visual Animation through the MOOCS Platform to Improve Understanding of Concepts. *Kasuari: Physics Education Journal (KPEJ)*, 7(2), 351–361. <https://doi.org/10.37891/kpej.v7i2.769>
- Yusuf, I., & Widyaningsih, S. W. (2017). Penerapan Laboratorium Virtual pada Mata Kuliah Eksperimen Fisika terhadap Keterampilan Berpikir Kritis Mahasiswa Pendidikan Fisika Universitas Papua. *Sainsmat: Jurnal Ilmiah Ilmu Pengetahuan Alam*, 6(1), 75-81. <https://doi.org/10.2685/sainsmat6164582017>