

# Development of E-Books Based on 4C Skills Through a Differentiation Approach to Science Learning

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**Abstract:** E-books are essential in developing 4C skills and differentiated learning because they offer accessibility and flexibility that support students' diverse learning styles. In addition, they allow customization of teaching materials according to students' needs, which increases motivation and learning independence. This research aims to develop an e-book based on 4C skills through a differentiated approach to valid, practical science learning. This study falls within the development research category that uses the ADDIE model. With an average validation score of 3.73, this e-book falls into the "very valid" category. In practical terms, this media is easy for teachers and students to use, fits the learning plan, and shows a learning implementation rate of 90%. Student responses were very good, with an average of 89.79% for four evaluation indicators, showing great benefits and a high level of satisfaction in the learning process. Overall, the e-book based on 4C developed through a differentiated approach to science learning can be categorized as valid and practical because it can increase student involvement in learning. In addition, interactive features in e-books support communication and collaboration between students, allowing them to share ideas and opinions. E-books also enable teachers to adapt material to individual needs so each student can learn at the pace and style they desire.

**Keywords:** Differentiation approach; E-book; Science learning

## Introduction

The advancement of technology and information in the 21<sup>st</sup> century has become a major driver in changing society to become more knowledgeable, with easy access to the internet providing a global source of knowledge. Teachers must equip students with the necessary skills to navigate the era of globalization and Industry 4.0, precisely the 4C (Critical thinking, Communication, Collaboration, Creativity) skills. The principles of 21<sup>st</sup> century learning prioritize integrating knowledge, thinking skills (critical, innovative, and problem-solving), use of technology, and research practices (Widodo & Wardani, 2020; Nasir & Andrew, 2022). 4C skills in science learning are essential to help students understand scientific concepts and apply these concepts to face increasingly complex global challenges. In the

age of Industry 4.0 and Society 5.0, 4C skills are needed in the world of work and social life, which increasingly requires individuals to be able to think critically, innovate, communicate effectively, and work together in teams (Indarta et al., 2022; Nurhayati et al., 2024; Rayhana, 2024).

An educator must design learning experiences that go beyond simply mastering the content, focusing also on fostering 4C skills that are essential for the demands of the 21<sup>st</sup> century (Mumtaziah & Majid, 2023). This will help students become better equipped to tackle future challenges in higher education or the workforce. Improving 4C skills can be achieved through school planning, teacher support, evaluation, and learning approaches. The learning approach that aligns with the independent curriculum is a differentiated approach, where the independent curriculum supports 21<sup>st</sup> century

## How to Cite:

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learning by providing freedom in designing a curriculum that integrates relevant skills and knowledge to face the challenges of the modern era. One of the learning approaches emphasized in the independent curriculum is the differentiated learning approach. Differentiated learning is an instructional approach tailored to address the individual learning needs of each student by considering their abilities, interests, and talents (Ni'mah, 2024; Safitri et al., 2024; Wahyuni, 2022). This approach allows students to actively participate in learning to enhance their critical and creative thinking abilities (Avandra, 2022; Rosa et al., 2024).

The differentiated approach can address students' needs by incorporating various learning styles, such as readiness, interests, and learning profiles, in one learning activity to achieve learning goals and improve learning outcomes (Aulia et al., 2024; Karmila, 2023). The goal of differentiated learning is to create a diverse classroom environment, offering students the opportunity to grasp the content, cultivate their ideas, and enhance their learning outcomes in an effective manner (Faiz et al., 2022).

Differentiated learning emphasizes the importance of the teacher's active role as the main driver in the learning process to analyze the situation and needs of students at school. This also creates challenges for teachers to attract and develop students' talents and interests, as well as helping students discover new interests. Teachers play a crucial role in developing students' 4C skills by adopting a differentiated learning approach. The future of education highlights the importance of teachers in creating adaptive, creative, and innovative learning experiences to meet the diverse needs of students. A key element in this process is the availability of learning resources supporting students' learning requirements. In today's educational landscape, digital resources are vital for fostering an inclusive learning environment. E-books, in particular, have become an essential digital tool in facilitating the learning process, as they provide effective media to support differentiated instruction, enabling teachers to tailor content and teaching methods to the unique needs and abilities of each student (Dhakar, 2023; Ratnasari & Ginanjar, 2019).

E-books can be customized to provide varied content and be accessible to students with various learning styles. This is achieved through the learning process with a differentiated learning approach that enhances student learning outcomes. By providing a learning environment to demonstrate their understanding according to their interests and abilities (Herwina, 2021). Through e-books, students can choose material that is relevant to their interests. Students can also access additional information that can deepen their

understanding of science concepts (Tanesib et al., 2022). E-books can also enhance 21<sup>st</sup> century skills, including critical thinking and collaboration. E-books can include interactive elements, such as quizzes and collaborative assignments, that encourage students to work together and think critically in solving problems (Sari et al., 2022; Basra, 2022). E-books function not only as a source of information in learning but as a platform for training students' social and cognitive skills. Conversely, learning that employs a differentiated approach can support students in developing critical thinking and creativity skills (Astria & Kusuma, 2023; Rahmah et al., 2022). For this reason, providing e-books that integrate differentiated learning approaches to facilitate 21<sup>st</sup> century skill is very important.

The integration of e-books in learning also plays a key role in addressing the challenges associated with traditional learning methods. In many cases, traditional learning is less able to meet students' learning needs, which causes dissatisfaction and low student learning motivation (Rusmiyati, 2023). By incorporating e-books, educators can provide a more flexible and personalized learning environment, enabling students to engage with content in a manner that aligns with their individual learning preferences (Ayuningtyas et al., 2023; Wahyuningsari et al., 2022). This is very important in the learning context in the post-pandemic era, where many students experience learning loss and require a more flexible approach to provide effective learning (Cahyono, 2023).

Based on the problems above, there is a growing demand for innovative digital teaching resources that are accessible anytime and anywhere, capable of addressing the varied needs of students, and aligned with the requirements of the 21<sup>st</sup> century, including the integration of 4C skills. The development of e-books based on 4C skills through a differentiated approach to science learning is an innovative solution to address students' diverse learning needs and learning styles as well as improving students' 4C skills.

## Method

This study is classified as a type of development research; in this case, what is being developed is the development of an e-book based on 4C skills through a differentiated approach. The learning development model used in this research refers to the ADDIE model in flow chart Figure 1 (Branch, 2009). It involves five stages, which are: Analysis, Design, Development (including validation testing, limited testing, and extensive testing), Implementation, and Evaluation. The analysis, design, and development stages are for validation tests and limited trials. Meanwhile, the stages

of implementation and evaluation will be carried out through socialization of the development of e-books based on 4C skills through a differentiated approach.

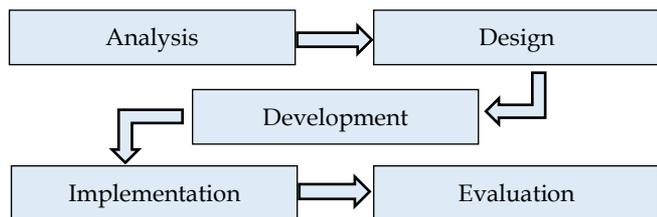


Figure 1. Flow chart of the ADDIE Model

This study will be conducted during the odd semester of the 2024/2025 academic year at SMP Negeri 4 Tilamuta. Development of e-book based on 4C skills through a differentiation approach has demonstrated validity and practicality, so the instrument used in this research is: First begins Instrument Validity. Validity of an e-book based on 4C skills through a differentiated approach was obtained from the results of expert validation using a validation sheet. This validation sheet is also used as a reference for revising the e-book based on 4C skills using a differentiated approach. In perfecting the media that has been prepared. The validation sheet that has been prepared is then submitted to the validator to assess the e-book and the assessment instrument. This validation sheet contains several assessment elements, namely structure, material, language, readability and appearance. This validation sheet includes the e-book based on 4C skills validation sheet using a differentiated approach.

Practicality Instruments of e-book based on 4C skills through a differentiated approach in this research was obtained from the implementation of Interactive learning media and student responses. Learning implementation observation sheet the observation sheet used is a learning implementation observation sheet, which aims to see the ease of using e-book based on 4C through a differentiated approach. The student response questionnaire sheet is used to collect information about student responses to the learning activities used in e-book based on 4C skills using a differentiated approach which was developed. The student response questionnaire concerns two aspects, namely student interest and student motivation.

In this research, data analysis was carried out using a quantitative descriptive analysis approach, namely describing quantitatively the quality of e-book development based on 4C skills through a differentiated approach. including validity, practicality, and effectiveness. The analysis used in this research is described as follows: First starts with validation analysis. The validator expert wrote his assessment of the e-book based on 4C using a differentiated approach

on the validation sheet. This validation process is carried out by two validators, and conclusions will be drawn based on the assessment results provided by both of them. The technique for analyzing learning media validation is used to be able to check whether the data resulting from the validation of the learning media being developed is suitable to proceed to the next stage. The formula used in validating is Aiken with reference to (Arikunto, 2010). The e-book based on 4C skills with a differentiation approach that has been designed can be used if it is declared valid or very valid by experts. Next, Practicality Analysis. Practicality of e-books based on 4C skills through a differentiated approach, it includes the practicality of using the interactive learning media developed. The practicality analysis developed in this research was obtained based on analysis of student responses and analysis of implementation in learning.

Analyze Student response data was obtained from a questionnaire that analyzed percentages and qualifications to draw conclusions about whether the interactive learning media developed received a good response from students. Instrument items use a Likert scale. Calculating the percentage of students' responses in learning is done using a percentage formula. Assessment of student responses is carried out by comparing the total average score obtained with predetermined criteria (Abdul et al., 2024; Sukardi, 2013). The e-books based on 4C skills through a differentiated approach, it is called practical from the aspect of student responses if 75% of students are in the good and very good categories. Analysis of learning practicality is also based on analysis of data resulting from observations of learning implementation. Assessment of the implementation of learning consists of two possibilities, namely whether it is implemented or not implemented.

## Result and Discussion

The focus of this research is to create the e-books based on 4C skills with a differentiation approach assisted by 3D Pageflip Professional for Learning, with main attention to validity and practicality. This e-book combines on 4C skills in a digital book designed to meet the needs of students with various learning styles. It is considered very important to prepare students to face the challenges of the 21<sup>st</sup> century, especially the Industrial Revolution 4.0 and Society 5.0 (Haryani et al., 2024).

The first stage is analysis. At this point, analysis is carried out to determine the concepts, assessments and learning specifications needed for media development. These specifications will be implemented in the e-book with subsequent analysis: Analysis The first stage is

front-end analysis, the aim is to analyze learning problems. This was done at the pre-research stage by interviewing teachers at SMP Negeri 4 Tilamuta. From these interviews, it was discovered that teachers used teaching materials that were not appropriate to students' abilities, which made learning boring. At this stage, the goal is to analyze learning problems. This was done at the pre-research stage by interviewing teachers at SMP Negeri 4 Tilamuta. According to educators, this analysis shows that teachers do not use learning materials that suit students' abilities, so learning becomes boring.

Analysis the second is concept analysis. Class VIII observations of Class VIII material concepts in the odd semester of the 2024/2025 academic year yielded results that were used as a reference framework in preparing e-book material. At this time the researcher decided to choose material about simple airplanes; this is one of the odd semester class VIII science materials. Next, analysis the third stage is the formulation of learning objectives. This stage aims to integrate the results from the previous stages and then determine the research object. The research object becomes a reference in designing and compiling the product being developed. Based on concept analysis, the learning objective that must be achieved is an interactive learning e-book.

After the definition stage, the researcher continued to the second stage, namely design. The first design stage begins with preparing the learning media framework. The e-books based on 4C skills framework has a display design that includes several elements. The learning material presented covers the topic of simple planes. In addition, learning can be done online, which allows students to access it anywhere and at any time. The results of the questions in the e-book can also be filled in directly by students. This textbook is equipped with 4C skills, so that students can get used to dealing with various existing problems.

The next design is Systematic and Material Design. The material in the e-book based on 4C is tailored to student needs, follows curriculum guidelines, and comes from references that are easily accessible and relevant to school textbooks. The selection of material also refers to a contextual approach so that it is more easily accepted by students. The next design is Instrument Design. This research uses a questionnaire as

a measuring tool. This instrument was prepared using a Likert Scale with four rating options: 1 is very invalid, 2 is not very valid, 3 is valid, and 4 is very valid. Before proceeding to the development stage, the researcher first carried out an assessment at each existing stage. The questionnaire instrument was adapted to meet research needs and added contextual elements. Questionnaires for teachers and students, as well as questionnaires for validators, have been adapted to determine how interesting the e-book based on 4C skills.

The third stage is in e-book product development to include a series of steps to produce an effective and useful product. This process begins with the creation of a first draft which has been validated by experts or validators. After going through the validation stage, this first draft was refined into a second draft that was ready for use. Next, a limited trial was carried out in a small class involving 15 students. This trial aims to test the effectiveness and feasibility of e-books in real learning contexts. The results of this trial were then analyzed in depth to assess the extent to which e-books can improve the student learning process. Based on the results of this analysis, improvements and improvements were made to the e-book to increase its effectiveness. The results of this validation and testing process are the basis for preparing better e-books, with the aim of creating products that are more practical and useful for students. These steps, namely the results of e-book validation and the practical results of trials, are the basis for developing optimal e-book products for learning.

First, it starts with the results of the e-book validation. This development research begins with expert validation. Two or more experts carry out the validation process, which is understood in two stages, namely validation of e-books and materials. Examiners provide input or suggestions regarding the results of the initial draft. The suggestions and input given by the examiners are then used as a reference to improve the e-book that has been previously created. E-books are the tools whose validity was tested in this research. The validation process is carried out by paying attention to various aspects, such as structure, content, readability, language and display design. During this validation process, the validator provides suggestions and input about the e-book that has been designed in Table 1.

**Table 1.** Shows suggestions and input

| Validators | Revised aspects       | Suggestions before revision   | After revision   |
|------------|-----------------------|---|--|
| 1          | Content aspects       | Add the 4C indicators and information about the existence in the e-book's foreword.         | 4C indicators and description of the 4C skills in the e-book foreword.       |
|            | Content aspects       | The questions in the e-book do not show critical thinking skills.                           | The questions in the e-book show critical thinking skills.                   |
| 2          | Aspects of appearance | Use personal documentation in e-books that are created either from documentation or created | The images in the e-book are sourced from my own edits and added references. |

by yourself. And if using someone else's documentation, then add references.

Results of Table 1, there are suggestions for several validator materials for making changes to the latest images or making your own modifications and adding references if using other people's data and making

improvements to the layout of the writing. All suggestions and input provided by material validators are presented in Figure 2-4.

**KATA PENGANTAR**

Assalamu'alaikum Warahmatullahi Wabarakatuh

Puji Syukur kehadiran Allah SWT yang senantiasa melimpahkan segala rahmat, taufik dan hidayah-Nya sehingga penyusun dapat menyelesaikan modul ini. Sholawat serta salam semoga senantiasa tercurah kepada junjungan kita Nabi Muhammad SAW, semoga kita semua mendapatkan syafaatnya di hari akhir nanti.

E-book ini disusun untuk memenuhi kebutuhan peserta didik yang memiliki gaya belajar yang beragam, baik visual, audio, bahkan audio visual. Pembahasan yang akan disampaikan pun disertai dengan soal-soal yang dapat digunakan untuk mengukur tingkat ketercapaian dan ketuntasan.

Penyusun menyadari bahwa di dalam pembuatan E-book masih banyak kekurangan, untuk itu penyusun sangat membuka saran dan kritik yang sifatnya membangun. Semoga modul ini memberikan manfaat serta menambah wawasan bagi kita semua.

Gorontalo, Juli 2024

Penulis

Before revision

**KATA PENGANTAR**

Assalamu'alaikum Warahmatullahi Wabarakatuh

Puji syukur kehadiran Allah SWT yang Maha Esa yang senantiasa melimpahkan rahmat, taufik, dan hidayah-Nya, sehingga penyusun dapat menyelesaikan E-Book ini dengan baik. Sholawat dan salam senantiasa tercurah kepada junjungan kita, Nabi Muhammad SAW, semoga kita semua mendapatkan syafaatnya di hari akhir nanti.

E-book ini disusun dengan mengacu pada keterampilan 4C (*Critical Thinking, Creativity, Communication, Collaboration*). Pentingnya kemampuan 4C karena memungkinkan individu dan tim untuk beradaptasi, berinovasi, dan bekerja sama secara efektif dalam menghadapi tantangan dan memanfaatkan peluang di dunia yang terus berubah. E-Book ini dirancang untuk mengakomodasi berbagai gaya belajar peserta didik, baik visual, auditori, maupun audio-visual. Setiap topik dilengkapi dengan soal-soal yang bertujuan untuk menilai pencapaian dan ketuntasan pembelajaran.

Penyusun menyadari bahwa dalam proses pembuatan E-book ini masih terdapat berbagai kekurangan. Oleh karena itu, kami sangat terbuka terhadap saran, dan kritik yang bersifat membangun demi perbaikan di masa mendatang. Semoga E-book ini dapat memberikan manfaat yang signifikan dan menambah dan memperluas wawasan pembaca secara menyeluruh.

Gorontalo, Juli 2024

Penulis

After revision

**Figure 2.** Information for fixed changes to the 4C Indicator and description of the 4C skills in the e-book preface

1. Sebuah pengungkit digunakan untuk memindahkan sebuah batu yang beratnya 900 N. Bila Panjang lengan kuasa adalah 120 cm dan lengan beban 20 cm, besar gaya minimum yang dibutuhkan adalah ...
2. Seorang anak hanya mampu mengerahkan gaya maksimum sebesar 100 N. Dengan sebuah tuas yang memiliki panjang lengan kuasa dan lengan beban berturut-turut 100 cm dan 20 cm, berapakah beban maksimum yang dapat diangkatnya?
3. Sebuah peti seberat 1.000 N hendak dipindahkan ke atas bak truk yang tingginya 1,5 m dengan bantuan bidang miring yang panjangnya 3 m. besar gaya yang diperlukan adalah ...
4. Sebuah tongkat panjangnya 180 cm akan dijadikan pengungkit untuk memindahkan beban yang beratnya 2.000 N agar hanya diperlukan gaya sebesar 400 N maka titik tumpu harus berjarak ... dari beban.

Before revision

**Tugas Keterampilan Berpikir Kritis Materi Roda Berporos**

Simaklah wacana dibawah ini dengan baik lalu diskusikan dengan teman kelompok dan jawablah pertanyaan dengan baik!

*"Roda berporos berfungsi sebagai pesawat sederhana dalam meningkatkan keuntungan mekanik pada sistem otot dan rangka manusia, dengan fokus pada pengangkatan beban"*

**Pertanyaan Indikator Keterampilan Berpikir Kritis:**

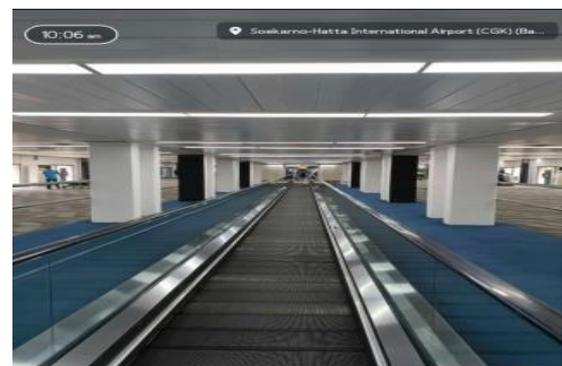
1. **Menfokuskan Pertanyaan:** Apa peran roda berporos dalam mengurangi beban kerja otot saat mengangkat objek?
2. **Menganalisis Argumen:** seberapa efektif roda berporos dibandingkan dengan cara pengangkatan tradisional.
3. **Bertanya dan Menjawab Pertanyaan Klarifikasi:** Ajukan pertanyaan seperti, "Apa asumsi dasar yang ada tentang penggunaan roda berporos?" Lalu, berikan jawaban berdasarkan observasi dan hasil penelitian.
4. **Mengobservasi dan Mempertimbangkan Hasil Observasi:** Amatilah bagaimana penggunaan roda berporos mempengaruhi tenaga saat mengangkat beban?
5. **Membuat Deduksi dan Mempertimbangkan Hasil Deduksi:** Dari observasi, deduksikan keuntungan mekanik yang diperoleh dan bagaimana ini memengaruhi kinerja otot.

After revision

**Figure 3.** Information for improvements to the questions in the e-book show critical thinking skills



Before revision



After revision

**Figure 4.** Information for changes were made to images and layout, as well as sources based on personal documentation

The results of the validation of the e-book which was developed quantitatively from the aspects of construction, content, language and readability are described in the following Table 2.

**Table 2.** E-book validation results of Teaching Materials

| Aspects                   | Indicators | Validator-1 | Validator-2 |
|---------------------------|------------|-------------|-------------|
| Construction              | 1          | 4           | 3           |
|                           | 2          | 3           | 4           |
| Contents                  | 3          | 4           | 3           |
|                           | 4          | 4           | 4           |
|                           | 5          | 3           | 3           |
|                           | 6          | 4           | 4           |
| Language                  | 7          | 4           | 4           |
|                           | 8          | 4           | 4           |
|                           | 9          | 4           | 4           |
| Legibility                | 10         | 3           | 4           |
|                           | 11         | 4           | 4           |
| Total                     |            | 40          | 41          |
| Maximum Score             |            | 44          | 44          |
| Average                   |            | 3.73        | 3.73        |
| Average of all validators |            |             | 3.73        |

The average value of the validation results is 3.73 and is included in the "very valid" category so that the e-book can be used with minor improvements. The evaluation results of these two validators show that the e-book developed is good and can be used in the learning process. Validation is an important process in developing teaching materials to ensure that the products produced are in accordance with learning objectives and student needs. Validation in this research was carried out by two validator experts who provided suggestions for improvement on several elements, including adding 4C skill indicators and improving test questions related to students' critical thinking abilities. Validators also emphasize the importance of using relevant documentation and providing appropriate references for teaching materials. With an average validation score of 3.73 out of 4, this e-book is included in the "very valid" category. These results indicate that e-books that meet valid aspects comply with high-quality standards and are suitable for use in learning (Pramita & Yulkifli, 2023).

This validation process is in accordance with previous research that emphasizes the importance of validity in developing e-book modules. Pramana et al. (2020) stated that validity is a key factor in developing e-modules so that they have an impact on the learning aspects to be achieved so that they can significantly improve student learning outcomes. Yanindah & Ratu (2021) also stated that well-validated e-modules can be effective in helping students learn in more depth. Validation of the e-book based on 4C developed in this research shows that this media has met the expected

validity requirements in the context of 21<sup>st</sup> century skills-based science education.

The second development stage in this project was the creation of an e-book of Practical Results, which aims to increase the practicality of the learning process. The practicality of this e-book is measured through two main indicators. First, is the implementation of learning which is carried out in accordance with the syntax of the learning model that has been planned previously. This ensures that each learning step is implemented systematically and in accordance with established methods. Second, provide questionnaires or surveys to students at the end of learning activities. This questionnaire is used to measure the extent to which students feel the benefits and effectiveness of learning, as well as to obtain feedback that is useful for improvement and further development. It is hoped that these two indicators can ensure that the Practicum Results e-book that is developed can truly support an effective and efficient learning process.

Results of Learning Implementation Data Analysis. The assessment for learning implementation aims to find out how practical e-book development is. Observers fill in learning implementation data during the learning process. Assessment of the implementation of learning for limited trials carried out at SMP Negeri 4 Tilamuta with a total of 15 students. From the results of observations, the average level of learning implementation by using information for I (Implemented) and NI (Not Implemented) was calculated as shown in Table 3.

**Table 3.** Implementation of learning using e-books

| Learning Activities    | Meeting-1 (%) |    | Meeting-2 (%) |    |
|------------------------|---------------|----|---------------|----|
|                        | I             | NI | I             | NI |
| Preliminary Activities | 75            | 25 | 100           | 0  |
| Core activities        | 100           | 0  | 100           | 0  |
| Closing Activities     | 67            | 33 | 100           | 0  |
| Average                | 81            | 19 | 100           | 0  |
| Average total aspects  |               |    |               | 90 |

Based on Table 3, the average learning implementation score was recorded at 90%, which was rated in the "very good" category. This description indicates that learning with the e-book developed can be considered practical, which means that its implementation is in accordance with a predetermined plan.

Results of Student Response Questionnaire. Data Analysis Student responses in this research are student responses to the use of the e-book that has been developed. Student response data was obtained from a 22-item student survey using a Likert scale assessment. A limited trial involving 15 students was used to collect student responses regarding the use of electronic books.

The results of the analysis of student responses to books presented electronically are in Table 4.

**Table 4.** Percentage results of student responses

| Indicators         | Percentage (%) | Category  |
|--------------------|----------------|-----------|
| Usefulness         | 89.00          | Very good |
| Ease of use        | 89.72          | Very good |
| Ease of learning   | 90.00          | Very good |
| Satisfaction       | 90.42          | Very good |
| Overall assessment | 89.79          | Very good |

As follows, the results of the average percentage of student responses are shown in Table 4. First, for the usability indicator, the average percentage of student responses reached 89.00, which is a very good category; second, for the ease-of-use indicator, the average percentage of student responses reached 89.72, which is a very good category; and fourth, for the satisfaction indicator, the average percentage of student responses reached 90.42, which is a very good category.

The practicality of e-books can be seen from how e-books are used in lessons and how students use them in learning activities. The level of learning implementation, with an average score of 90%, shows that e-books are very effective for use in classes with different learning approaches. The overwhelmingly positive student comments show how practical the e-book is. The results show that the e-book developed has met the practicality criteria and can help students' learning process in science lessons, with indicators such as function, ease of access, learning comfort, and student satisfaction getting a score of more than 89% and an average score of 89.79%. These results are in line with previous research findings which show that e-books (Pramita & Yulkifli, 2023).

E-books that integrate a differentiated learning approach emphasize student-centered learning processes so that they can train students' independence and collaboration. Zhao et al. (2023) in his research showed that the 4C skills e-module for vocational students significantly helped students in independent and collaborative learning. Another study conducted by Santika et al. (2020) shows that the integration of 4C skills in pedagogical e-books is able to improve learning through a student-centered approach. The practicality of e-books in this research reflects the ability of e-books to support more adaptive and efficient learning as an important component in 21<sup>st</sup> century learning.

The application of e-books in science learning shows an increase in student learning activities. This shows that this e-book has succeeded in increasing student involvement in the learning process. The use of 21<sup>st</sup> century skills-based e-modules can effectively improve students' collaboration and communication

abilities (Zhao et al., 2023). Furthermore, this e-book is also designed to support differentiated learning, allowing teachers to adapt materials and teaching methods to the specific needs of each student. Personalized learning has proven to be effective in improving student learning outcomes, because it provides opportunities for them to learn in a rhythm and manner that suits their individual preferences (Chidiac & Ajaka, 2018). Previous research by Anggreni & Yohandri (2022) also revealed that e-books based on discovery learning can help students develop critical and creative thinking skills, two main skills in developing 4C competencies. Therefore, this e-book not only supports individual learning, but also encourages collaborative interactions between students, which is essential for developing 21<sup>st</sup> century skills.

The development of e-books based on 4C through a differentiation approach has several important implications for science education. First, this e-book provides flexibility for students to learn in a way that suits their learning style and can significantly increase student engagement and motivation in learning. Second, this e-book also encourages the development of collaboration and communication skills through interactive features that allow students to share ideas and work together in groups.

These findings are consistent with research by Azzahra et al. (2024) which shows that 4C-oriented e-books using a case-based reasoning approach that emphasizes student-centered learning can improve student learning outcomes in physics material. Besides that, Haryani et al. (2024) emphasizes the importance of pedagogical strategies that integrate 21<sup>st</sup> century skills in science learning, stating that approaches focused on individual student needs can effectively increase student engagement in the learning process.

This e-book has a very significant impact in improving the quality of science learning at the secondary school level. By integrating the 4C skills approach and differentiated learning, this e-book gives teachers the ability to design more inclusive, adaptive, and effective learning experiences. This approach allows teachers to adapt teaching materials and strategies according to the needs and potential of each student, thereby creating a learning environment that is more dynamic and responsive to the diversity of student learning styles.

Additionally, this e-book focuses not only on mastering scientific concepts, but also on developing indispensable 21<sup>st</sup> century skills, such as 4C skills. In this way, students not only achieve a better understanding of science subject matter, but are also trained to develop relevant skills in everyday life and the professional world of the future. In this context, this e-book makes an

important contribution in preparing students to face the increasingly complex challenges of the 21<sup>st</sup> century, while improving their overall learning outcomes.

The application of technology through e-books also expands learning access for students, giving them the freedom to learn independently and at their own pace. This really supports the creation of more flexible learning, where students can explore a variety of resources, access additional material, and deepen their understanding of certain topics. In this way, this e-book is not only an effective learning tool, but also supports the development of key skills necessary for success in an ever-evolving world.

## Conclusion

Development of e-books based on 4C skills through a science learning approach has proven to be valid and practical. With an average validation score of 3.73, this e-book falls into the "very valid" category. In practical terms, this media is easy for teachers and students to use, fits the learning plan, and shows a learning implementation rate of 90%. Student responses were very good, with an average of 89.79% for four evaluation indicators, showing great benefits and a high level of satisfaction in the learning process. Overall, the e-book based on 4C developed through a differentiated approach to science learning can be categorized as valid and practical because it can increase student involvement in learning. In addition, the interactive features in e-books support communication and collaboration between students, allowing them to share ideas and opinions with each other. E-books also allow teachers to tailor material to individual needs, so each student can learn at their desired pace and style.

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The authors declare no conflict of interest

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