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Development of Interactive e-Book Based on Chemical Representation on Electrolysis Cell Topic

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Abstract: Development of Interactive E-Book Based on Chemical Representation on Electrolysis Cell Topic. This research was aimed to develop an interactive e-book and describe its characteristics and validity as well as to describe the teachers' and students' responses of interactive e-book was developed. The research design used Borg and Gall method of research and development which only carried out until the fifth stage, namely the revision stage of the trial results. The data obtained were analyzed using descriptive statistical analysis. Characteristics of interactive e-book based on chemical representation of the electrolysis cell topic was developed, starting with discourses related to everyday life phenomena accompanied by pictures based on chemical representation, equipped with identification columns, explanation columns, observation tables and interactive questions. The results of expert validation on the aspects of content suitability, construction and readability all have very high criteria. Based on this, the interactive e-book based on the chemical representation on electrolysis cell topic is said to be valid. In addition, the results of the teacher's responses to aspects of the suitability of content, construction and readability as well as the results of student responses to aspects of attractiveness and readability each have very high criteria.

Keywords: interactive e-book, chemical representation, electrolytic cell

Abstrak: Pengembangan E-Book Interaktif Berbasis Representasi Kimia Pada Topik Sel Elektrolisis. *Penelitian ini bertujuan untuk mengembangkan e-book interaktif dan mendeskripsikan karakteristik dan validitasnya serta mendeskripsikan tanggapan guru dan siswa terhadap e-book interaktif yang dikembangkan. Desain penelitian menggunakan metode penelitian dan pengembangan Borg and Gall yang hanya dilakukan sampai tahap kelima yaitu tahap revisi hasil uji coba. Data yang diperoleh dianalisis menggunakan analisis statistik deskriptif. Karakteristik e-book interaktif berbasis representasi kimia topik sel elektrolisis dikembangkan, dimulai dengan wacana terkait fenomena kehidupan sehari-hari disertai dengan gambar berbasis representasi kimia, dilengkapi dengan kolom identifikasi, kolom penjelasan, tabel observasi dan pertanyaan interaktif. Hasil validasi ahli pada aspek kesesuaian isi, konstruksi dan keterbacaan semuanya memiliki kriteria sangat tinggi. Berdasarkan hal tersebut maka e-book interaktif berbasis representasi kimia pada topik sel elektrolisis dikatakan valid. Selain itu, hasil tanggapan guru terhadap aspek kesesuaian isi, konstruksi dan keterbacaan serta hasil tanggapan siswa terhadap aspek daya tarik dan keterbacaan masing-masing memiliki kriteria sangat tinggi.*

Kata kunci: *e-book interaktif, representasi kimia, sel elektrolisis*

• INTRODUCTION

The era of globalization and advances in information technology is a challenge for the future of the Indonesian nation. The higher demands on production technology have an

impact on the need to improve the quality of human resources. In this case, education has an important role in efforts to improve the quality of human resources (Sari, et al ., 2020). As stated in Law no. 20 of 2003 concerning the National Education System, especially Article 3, the purpose of implementing national education is essential to improve the quality of human resources. To achieve these educational goals, a quality learning process is needed (Semiawan & Soedijarto, 1991). Many factors can support the realization of a quality learning process to achieve education, one of which is the use of appropriate learning resources (Nurbaity, 2011). Currently, the learning resources that are widely used by teachers are textbooks from certain publishers.

The textbooks used tend to be informative so that only unidirectional communication occurs and tends to be passive (Munadi, 2008). Learning resources used by teachers should be more interactive which can make students interested and happier to use these learning resources. The existence of advances in information and communication technology allows learning materials to be stored in various forms of technology that are more effective and efficient, for example in the form of e-books or electronic books (Sanjaya, 2008).

An e-book is a set of textbooks consisting of text, images, or sound presented in digital form or textbooks that are converted into digital formats or certain electronic files that can be viewed or read on screens of all types of devices (Wang, 2015).). E-books can present all types of material in audio and visual forms including speech, text, music, animation, photos, videos, or in different combinations. Something impossible to be presented in a textbook because of its limitations can be presented in the form of electronic media (Sanjaya, 2008).

The use of interactive learning media such as e-books can have a good influence on students. Students become more enthusiastic about learning, have learning independence and high self-confidence, and can develop their learning creativity (Apriandi, Suprapto, & Pamungkas, 2019). In addition, the use of interactive e-books in learning is quite effective in improving students' critical thinking skills and communication skills as well as effective in improving students' conceptual understanding (Nizatama, Rudibiyani, & Sofya, 2017; Sari, Fadiawati, & Tania, 2017; Rosida, Fadiawati, & Jalmo, 2019). This shows that the use of interactive e-books is very supportive if used in learning activities, including in learning chemistry at school.

Chemistry is considered a difficult subject to learn because it consists of abstract concepts and topics. The complex and abstract nature of chemistry makes teaching and learning difficult for students and teachers (Johnstone, 1991; 1993; Nakhleh, 1992; Gabel, 1998; Treagust & Chittleborough, 2001). Understanding most concepts in chemistry depend on understanding at the microscopic level the chemical phenomena, both of which are communicated by symbols. Thus, conceptual understanding in chemistry includes the ability to represent and translate chemical problems using representational forms at the macroscopic (observable), microscopic (particulate), and symbolic levels (Gabel & Bunce, 1994).

One of the materials in chemistry subjects in high school is electrolysis cells. In the material of electrolysis cells, several concepts are abstract, for example in terms of the movement of electrons, the flow of electric current, and the movement of ions. Abstract concepts that exist in the material of electrolysis cells are often considered difficult by students. This is because students tend to have difficulty representing the submicroscopic level and connecting macroscopic, submicroscopic, and symbolic phenomena (Farida, 2009; Fatmawati, 2013). It is suspected that these difficulties occur due to the lack of visualization of learning on chemical representations at the sub-microscopic level (Farida, 2009). Textbooks that are used as the main source in the learning process of electrolysis cell material do not cover the three levels of chemical representation. In this case, the use of learning resources in the form of interactive e-books that cover all three levels of chemical

representation is needed to improve students' conceptual understanding of the electrolysis cell topic.

Based on preliminary research conducted at two public high schools in Bandar Lampung City and one public high school in the Bogor district, information was obtained that only 33.3% of teachers used e-books in learning electrolysis cell material, and the e-books used were e-books. the books downloaded from the internet and the e-books are not interactive e-books. Furthermore, based on filling out the questionnaire, information was also obtained that 66.7 % of teachers did not know about the three levels of representation in chemistry.

The results of filling out student questionnaires totaling 30 respondents from two high schools in Bandar Lampung City and 1 high school in Bogor Regency showed that only 33.3% of students used e-books as a learning resource in learning electrolysis cell material. Based on filling out the questionnaire, all teachers and students stated that it was necessary to develop learning resources in the form of interactive e-books on electrolysis cell material and hoped that the e-books that would be developed later contained pictures of the macroscopic, submicroscopic, and symbolic levels, had easy-to-understand language, and contains interactive evaluation questions.

Based on this description, this article will describe the results of the development of an interactive e-book based on chemical representations of electrolysis cell material which aims to describe the characteristics and validity of interactive e-books, as well as describe the responses of teachers and students regarding interactive e-books.developed.

- **METHOD**

Research and Information Collecting

The first stage carried out in this research is research and information collection. This stage consists of two steps, namely literature study and field study. Literature studies were conducted in the form of KI and KD analysis, indicators, concept analysis on electrolysis cell material, analysis related to chemistry learning resources, interactive e-books chemical representations, and interactive e-books that have been developed by previous researchers.

Field studies were conducted at SMA Negeri 14 Bandar Lampung, SMA Negeri 15 Bandar Lampung, and SMA Negeri 1 Cibungbulang. The data sources at this stage were 3 chemistry teachers and 30 students of class XII science by filling out a needs analysis questionnaire through google forms for chemistry teachers and students of class XII science. The instrument used to obtain data is in the form of a needs analysis questionnaire. Furthermore, the data obtained were analyzed using the following formula:

$$\% J_{in} = \frac{\sum Ji}{N} \times 100\%$$

Where % J_{in} is the percentage of answer choices I, Jin is the number of respondents who answered the answer i, and N is the total number of respondents.

Planning

The planning stage includes the design of the product to be produced and the product development process. According to Sukmadinata (2015), the product design to be developed at least includes (1) the purpose of using the product, (2) who the users of the product, and (3) a description of the product components and their use.

Develop Primary Form of Product

Initial product development is carried out by compiling an initial draft of the e-book along with the components contained in the draft. After the interactive e-book was developed, product validation was carried out by two validators. Aspects that are validated are aspects of the suitability of the content of the material, aspects of construction, and

aspects of readability. Then, the data from the validation results were analyzed using the formula:

$$\%X\,in = \frac{\sum S}{Smaks}\ X\ 100\%$$

Where % X in is the percentage of answers to the i-questionnaire, $\sum S$ is the number of answer scores and Smaks is the maximum score (Sudjana, 2005). The scoring of respondents' answers in the questionnaire is based on the Likert scale which can be seen in table 1.

Table 1. Scoring of the questionnaire based on the Likert scale (Sugiyono, 2010)

No.	Answer Options	**Score**
1.	Strongly Agree (SA)	5
2.	Agree (A)	4
3.	Disagree (D)	3
4.	Disagree (D)	2
5.	Strongly Disagree (SD)	1

After calculating the percentage of answers to each question in the questionnaire, the next step is to calculate the average percentage of answers to each questionnaire to determine the level of conformity of the material content, construction, and readability of the e-book with the formula as follows:

$$\%\bar{X}i = \frac{\sum \%\ Xin}{N}$$

Where $\%\bar{X}i$ is the average percentage of the i-questionnaire, $\sum\%X_{in}$ is the total percentage of the i-questionnaire and N is the number of questionnaire questions (Sudjana, 2005). The results of the calculation of the percentage of the questionnaire as a whole are interpreted using the criteria in Table 2 below.

Table 2. Interpretation of the percentage of questionnaires (Arikunto, 2008)

Percentage (%)	**Criteria**
80,1 % - 100	Very high
60,1 % - 80	Tall
40,1 % - 60	Currently
20,1 % - 40	Low
0,0 % - 20	Very Low

Then calculate the average percentage of the three aspects (content suitability, construction, and readability). This calculation is used to determine the level of product validity from expert validation using the criteria shown in Table 3 below.

Table 3. Validation criteria (Arikunto, 2008)

Percentage (%)	Validity level	Information
100 – 76	Valid	Worthy
75- 61	Quite valid	Decent enough
60 – 26	Not valid	Not wort it
<26	invalid	Not feasible

Preliminary Field

At this stage, the e-book was tested on three chemistry teachers and 30 students of class XII IPA 3 at SMA Negeri 15 Bandar Lampung. The trial process was carried out by giving instruments in the form of questionnaires and giving the initial product that had been made to find out responses to aspects of the suitability of the content, construction, and product readability to the teacher, as well as the attractiveness and readability of the product to students. The data obtained for each aspect is calculated using the formula % Xin and % Xi above, then interpret as the average percentage using Table 2.

Main Product Revision

The last stage of this research is the revision and refinement of an interactive e-book based on chemical representations of the developed electrolysis cell material. The revision stage was carried out based on the results of teacher and student responses to the developed interactive e-book.

- **RESULT AND DISCUSSION**

The product produced in this development research is a student worksheet based on information literacy through a guided inquiry approach on acid-base material developed using the ADDIE development model.

Results of Research and Information Collecting

The research and information collecting phase consisted of a literature study and a field study. Based on the results of the literature study, an analysis of KI-KD was obtained, an analysis of the concept of electrolytic cell material, and the results of a theoretical study of e-books from the results of previous studies related to interactive e-books based on chemical representations of electrolytic cell materials. The results of this study are used as a reference in the preparation of an interactive e-book based on chemical representations of the developed electrolysis cell material.

The results of the field study obtained data through filling out a questionnaire by three chemistry teachers and 30 students of class XII science spread over three schools. Based on the results of filling out the needs analysis questionnaire at the field study stage, information was obtained that e-books are still rarely used as a learning resource in electrolysis cell learning, both teachers and students use textbooks and the internet more as sources. Teachers' understanding of the three levels of chemical representation is also still low, which causes the application of three levels of chemical representation to study electrolysis cells to be also

still low. This shows that it is necessary to develop an e-book based on the chemical representation of the electrolysis cell material.

Planning Results

The product planning stage includes the design of the product to be produced and the product development process. The purpose of using this interactive e-book product is to assist students in learning chemistry, especially electrolysis cell material. The developed e-book contains material on electrolysis cells based on chemical representations and is equipped with interactive questions. The purpose of using e-books for teachers is to assist teachers in creating interactions, especially interactions between students and learning resources in the learning process. The users of this product are chemistry teachers and class XII, students.

The components of an interactive e-book based on a chemical representation of the electrolysis cell material that will be developed include an outer cover, an author's inner cover, a preface, a list of materials, an e-book description, instructions for using the e-book, basic competencies, and indicators, and material descriptions equipped with pictures or videos based on chemical representations, interactive evaluation questions at the end of the material, bibliography, and back cover.

Result of Development of Interactive E-book Based on Chemical Representation

At the development stage, a complete e-book draft is prepared along with the e-book components including an outer cover, inner cover, preface, list of materials, e-book description, e-book usage instructions, basic competencies and indicators, and interactive evaluation questions at the end. materials, bibliography, back cover, and material descriptions equipped with pictures or videos based on chemical representations. The existence of pictures, animations, and videos based on chemical representations will help students to more easily learn the material of electrolysis cells. This is supported by Mashuri (2014) who says that most of the students stated that the sub-microscopic animation media helped them understand the material more easily, then the sub-microscopic animation media it could make abstract concepts more real and help students remember the material well. Applications used in e-book development These interactive tools are Flip PDF Professional and Macromedia Flash 8.

E-book construction consists of three parts, namely beginning, content, and closing. The first part consists of an outer cover, an inner cover, an introduction, a list of materials, and an interactive e-book introduction. The outer cover is designed as attractive as possible to attract student's interest to learn the contents of this interactive e-book. part of the outer cover is designed using the dominant colors of light blue and yellow. On the outer cover, the title of the interactive e-book is displayed, the curriculum used as a reference for the preparation of the e-book, the name of the author, and pictures related to the material of electrolysis cells are displayed. The inner cover is designed to be simpler than the outer cover with a dominant black and white color. While the introduction to the interactive e-book contains a description of the e-book, instructions for using the e-book, and the benefits of using the e-book.

The interactive e-book content section contains a description of the basic competencies and indicators as well as a description of the material. In general, the material in this interactive e-book is organized into two main topics, namely electrolytic cells and Faraday's Law. Each sub-material in this interactive e-book is equipped with pictures, experimental videos, submicroscopic animations, identification columns, and explanation columns.

The closing part of the e-book consists of evaluation questions, a bibliography, attachments, and a back cover. The evaluation questions in this e-book are interactive, students can find out directly whether the chosen answer is right or wrong. At the end of the

evaluation questions, students can see the final score obtained after working on the evaluation questions. The bibliography contains the sources of material used in the interactive e-book, while the back cover of this e-book contains the bio-data of the author of the interactive e-book.

Results of Expert Validation

After the interactive e-book based on the chemical representation of electrolysis cell material has been developed, the next step is product validation by 2 lecturers of Chemistry Education, University of Lampung. Expert validation includes the validation of aspects of content suitability, construction aspects, and readability aspects. This validation is done by providing an interactive e-book product as a result of development and validation questionnaires to the validator. Then the validator will provide an assessment of the statements contained in the questionnaire and write suggestions for improving the interactive e-book that has been developed.

The average percentage of assessments from the two validators on interactive e-books based on chemical representations of electrolysis cell material can be seen in Figure 1.

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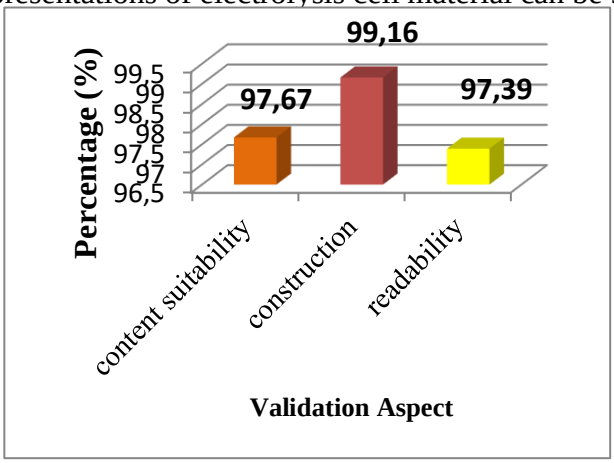


Figure 1. the Average percentage of validator assessments of interactive e-book based on chemical representations of electrolysis cell material

Aspects of content suitability include conformity of indicators with KD, suitability of the content of material with KD and indicators, and conformity of content of material with chemical representation. In Figure 1 it can be seen that the average percentage of content conformity aspects is 97.67 %. Based on Arikunto's interpretation (2008) which can be seen in Table 2, the results of expert validation on the aspect of content suitability are included in the very high criteria. In this aspect, the two validators did not provide suggestions for improvement, so it can be said that the interactive e-book based on the chemical representation of electrolysis cell material has material content that is by KD and also chemical representation.

The construction aspect includes the completeness of the components of the e-book and the sequence of material descriptions in the interactive e-book. Based on the percentage of expert validation data in Figure 1, it can be seen that the average percentage of construction aspects is 99.16 %. Based on Arikunto's interpretation (2008) in Table 2, it can be said that the results of expert validation on the construction aspect are included in the very high criteria.

In the construction aspect, validator 2 provides suggestions for adding the benefits of using the developed interactive e-book. Based on these suggestions, the introduction page for interactive e-books has changed with the addition of the benefits of using interactive e-

books as shown in Figures 2a and 2b below.

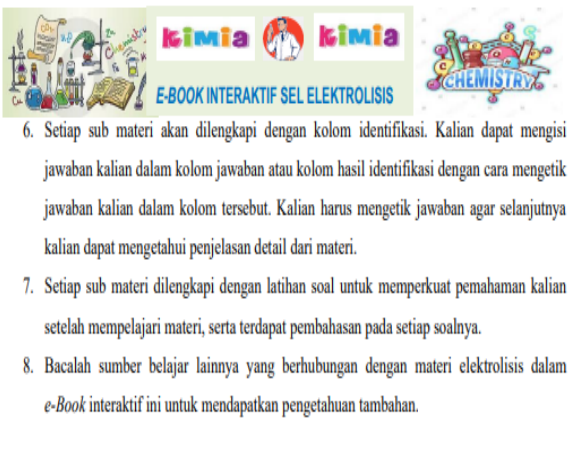
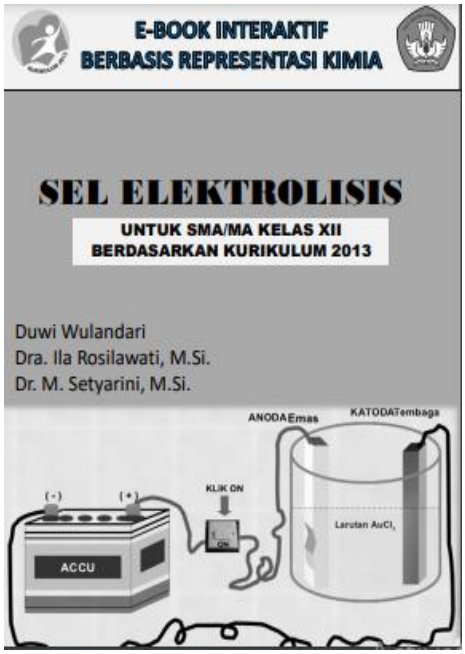


Figure 2a. Introduction page before revision

Figure 2b. Introduction page after revision

Readability aspects include font, font size, color combination, image quality, and table clarity, as well as the language used in interactive e-books. In Figure 1 the average percentage of readability aspects of interactive e-books is 97.82 % which is included in the very high criteria.

According to validator 2, the picture of the electrolysis cell circuit on the inner cover is not clear and suggests using a color image so that the image presented looks clearer. Based on these suggestions, the cover of the interactive e-book has changed as shown in Figures 3a and 3b below.



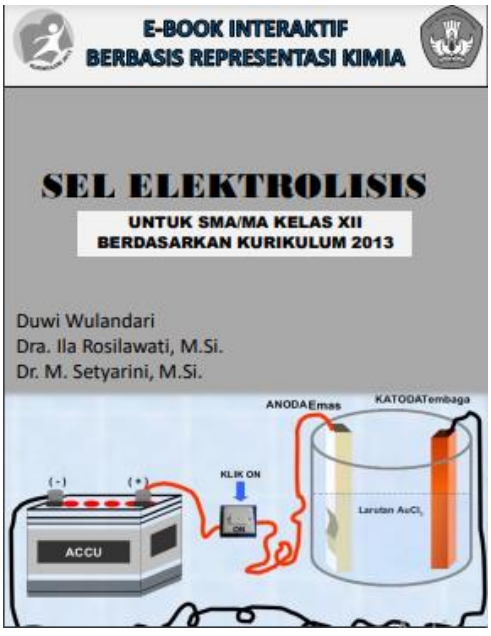


Figure 3a. Inner cover before revision **Figure 3b.** Inner cover after revision

Based on the assessment by the validator on the aspects of content suitability, construction aspects, and readability aspects, the criteria are very high. Thus, it can be said that the interactive e-book based on the chemical representation of the electrolysis cell material developed is valid according to Arikunto's (2008) interpretation.

Result of Pleminary Field

Pleminary Field were conducted at SMA Negeri 15 Bandar Lampung. Respondents in this pleminary field were three chemistry teachers and 30 students of class XII IPA 3. The initial field trial process was carried out by giving instruments in the form of questionnaires and giving initial products that had been validated and improved. The teacher's response questionnaire includes an assessment questionnaire on aspects of content suitability, construction, and readability. The average percentage of the pleminary field results for teachers can be seen in Figure 4 below.

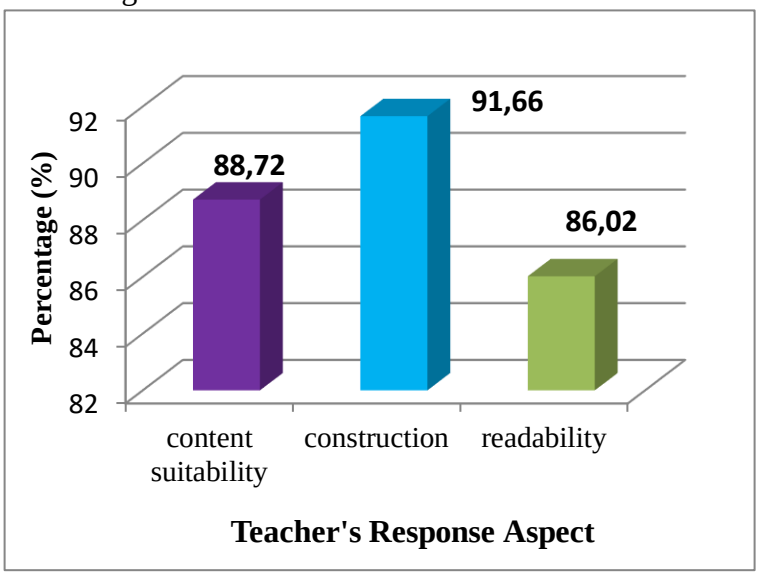


Figure 4. The Average percentage of initial field trial results for teachers

In Figure 4, it can be seen that the average percentage on the aspects of content suitability, construction, and readability are 88.72 %, 91.66%, and 86.02 %, respectively. Based on Arikunto's interpretation (2008) which can be seen in Table 2, the results of the initial field trial on teachers on aspects of content suitability, construction, and readability are all included in very high criteria. At this stage, the teacher does not provide any suggestions for improvement, so it can be said that the interactive e-book based on chemical representations developed already has material content that is by KD and also follows chemical representation. In addition, the developed interactive e-book also has good construction and readability.

Student response questionnaires include an assessment questionnaire on aspects of attractiveness and readability. The average percentage of pleminary field results on students can be seen in Figure 5 below.

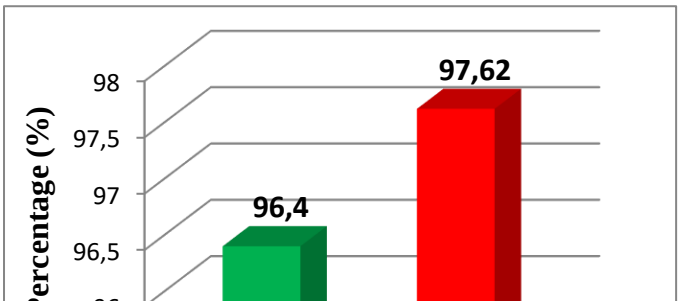


Figure 5. The Average percentage of pleminary field results among students

In Figure 5 it can be seen that the average percentage in the readability and attractiveness aspects is 96.4% and 97.62%, respectively. Based on Arikunto's interpretation (2008) which can be seen in Table 2, the results of the initial field trials on students on aspects of readability and attractiveness are all included in the very high criteria. At this stage, the students did not provide any suggestions for improvement, so it can be said that the interactive e-book based on chemical representations of the electrolysis cell material developed had good readability and attractiveness.

Main Product Revision

The last stage of this research is the revision and improvement of the interactive e-book based on chemical representations of the developed electrolysis cell material. The revision stage was carried out based on the results of the teacher's responses and student responses to the developed product. Based on the responses of teachers and students, there were no inputs and suggestions for the products developed so there was no need for revision.

Characteristics of Developed Interactive E-Book

The e-book that was developed is an interactive e-book based on chemical representations of electrolytic cell material. The developed e-book has an.exe format so that it can be used on a computer or laptop. The learning material in the e-book is divided into two subjects, namely electrolytic cells and Faraday's Law. The subject of electrolysis cells includes material on the components in an electrolysis cell, types of electrodes, the process of electrolysis of melts and solutions with inert electrodes, the process of electrolysis of solutions using non-inert electrodes, and examples of the application of electrolysis in everyday life. The subject matter of Faraday's Law includes Faraday's Law 1, Faraday's Law 2, and calculations related to Faraday's Law. This makes it easier for students to learn and understand the material gradually.

The interactive e-book material is equipped with discourses related to everyday life phenomena and is equipped with pictures that support the material for electrolysis cells. Each sub-material in the e-book is also equipped with pictures, videos, and animations based on chemical representations.

The e-book is equipped with an identification column and a table of observations that can be filled in by students to explore their knowledge from observing and identifying phenomena or experimental videos in the e-book. The interactive e-book is also equipped with an answer column containing explanations regarding the problems identified by students to make it easier for students to better understand the problems they have identified. In addition, at the end of the interactive e-book, it is equipped with interactive evaluation questions so that students can know their ability to understand the material that has been

studied in electrolysis cells.

- **CONCLUSION**

The conclusion obtained in this study is the production of an interactive e-book based on chemical representations of electrolysis cell material which is equipped with discourses related to phenomena in everyday life, equipped with pictures, experimental videos, and animations based on chemical representations, equipped with identification columns, explanation columns, tables results of observations and interactive evaluation questions. Expert validation results and results The results of the teacher's responses in the initial field trials which include aspects of content suitability, construction, and readability have very high criteria. In addition, the results of student responses in the initial field trial which included aspects of attractiveness and readability aspects also had very high criteria. Based on this, the interactive e-book product based on the chemical representation of the electrolysis cell material produced in this study can be said to be valid.

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