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Development of Learning Media Integrated Module Application Based on Socio-Scientific Issues Enriched Augmented Reality on Electrolysis Cell Material

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This study aims to develop learning media integrated module applications based on socio-scientific issues enriched by augmented reality on electrolysis cell material and test the feasibility and validity of chemistry learning media products developed. The research method used is research and development (R&D) using the 3D model adopted from the 4D model developed by Thiagrajan et al. (1974: 5), which consists of 3 stages, namely: define, design, and development. This research is only limited to the development stage. The instruments used in this research are validation and readability test questionnaires. The validators consisted of 2 people, namely one lecturer from the Chemistry Department of the State University of Malang and one chemistry teacher from SMAN 2 Batu, as media and material experts. The readability test was conducted on 29 undergraduate students of the Chemistry Education class 2022 at the State University of Malang, assuming they had taken the subject during class XII in senior high school. The results showed that the validity of the material and media included very feasible criteria with 98.24% and 96.81%, respectively, in addition to the average of all aspects of the readability test assessed having a percentage of 91.77%.

Graphical abstract

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1. Introduction

Chemistry is one of the subjects in high school that is considered difficult for most students. That is because chemistry contains many abstract and complex concepts that students need help understanding [14]. Understanding chemistry as a whole requires an understanding of three aspects of representation: macroscopic, submicroscopic, and symbolic aspects, with the three aspects interrelated with each other [5]. Students need help understanding the three

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aspects of representation because, currently, chemistry learning uses more representations at the macroscopic and symbolic levels [20]. Therefore, one of the important factors for students to understand chemical material is their ability to represent chemical phenomena submicroscopically [15]. Previous research shows that students' inability to represent submicroscopic aspects impacts their ability to solve chemical problems in macroscopic and symbolic aspects [20].

Electrolysis cell material is an abstract and complex chemical topic that requires an understanding submicroscopic representation aspect to explain macroscopic and symbolic phenomena [12]. This material is taught in the odd semester of class XII, the SMA equivalent. This material discusses the relationship between chemical reactions and electric current, which contains the concepts of redox reactions, ionization, and invisible ion/electron migration [10]. The characteristics of the material mentioned require students to have the ability to visualize good submicroscopic aspects.

Visualization ability is essential because it allows students to represent chemical concepts as a whole [22]. However, students need help representing the concepts and processes in electrolysis material submicroscopically. They need help understanding the material [4]. The low ability of students to represent electrolysis cell material can be caused by the unavailability of learning media that can visualize material submicroscopically [6]. In line with this, the results of preliminary observations and interviews with chemistry teachers at SMAN 2 Batu show that in chemistry learning, the learning media used by teachers are PPT, BSE books, and Google Classroom. The three media mostly use macroscopic and symbolic representations, while submicroscopic representations are still minimal, so students experience difficulties and boredom in understanding electrolysis cell material. This is supported by the findings of research conducted by Puspitasari & Sukarmin [11] that learning media has an essential role so that students can visualize chemical processes in electrolysis cell material, especially in electron movement.

Following up on the problems encountered, learning media plays an essential role as a tool to help students visualize electrolysis cell material through three aspects of representation. This is reinforced by the opinion of Andriani & Guspatni [2] that to be able to visualize the concept of electrolysis cells, multiple representation-based learning media are needed. Nowadays, based on the learning mandate in Curriculum 2013, students' activeness in learning is required, so it is necessary to develop learning media that students can use anywhere and anytime [17]. Based on this, printed learning media in the form of modules equipped with attractive images is a solution to help students represent the concept of electrolysis cell material.

Today, technology is developing rapidly, impacting the development of learning media. Learning media in this era is no longer only in books or conventional media but can take the form of smartphone applications [23]. Learning media in applications are flexible, so students can use them repeatedly according to their willingness and readiness [8]. Apart from learning media in the form of applications, another use of technology in developing learning media is augmented reality (AR) technology [3].

Augmented reality (AR) is a technological innovation that combines real and virtual objects into three-dimensional (3D) objects that are interactive in real-time [13]. This three-dimensional (3D) model can visualize objects not visible in the learning process [7]. Therefore, this technology can be used by students as learning media to visualize submicroscopic chemical material, especially to explain the submicroscopic aspects of electrolysis cell material. Currently, the development of augmented reality-enriched media mainly focuses on molecular geometry and chemical bonding materials, such as in the research of Zalfie et al. [24] and Apriani et al. [3]. However, there still needs to be more development of learning media enriched with augmented reality in electrolysis cell material. Currently, the development of AR media in electrolysis cell material is limited to the basic concepts of solution electrolytic cells [9]. AR has not been developed in electrolysis cells in everyday life applications. Therefore, AR technology has the potential to be developed into chemistry learning media on electrolysis cell material, especially in the application of electrolysis cells in everyday life, so an integrated module learning media enriched with augmented reality was chosen.

The learning media to be developed is based on socio-scientific issues (SSI). SSI-based learning links issues that develop in society to science [1]. Socio-scientific issues (SSI) are open-ended to motivate critical thinking and discussion of existing issues with different perspectives for students [25]. This makes socio-scientific issues very interesting when used in scientific discussion activities during the learning process. The SSI learning approach is intended to make the chemistry learning process more meaningful, namely learning that can connect science with problems in the surrounding environment [16]. In addition, SSI learning is also helpful for training students to think at a high level to solve various problems of everyday life [16].

One example of a problem related to electrolysis cells is that often, the rims of vehicles experience rusting when exposed to water and air. Suppose this is allowed to cause tire damage. It can cause road accidents for the driver of the vehicle. Overcoming this problem is closely related to electrolysis cells because one way to overcome this phenomenon is by electroplating or coating other elements on the surface of the rim. In addition, many more problems are closely related to electrolysis cell material in everyday life. Using SSI-based learning media is relevant so students can relate their conceptual understanding of electrolysis cell material to social phenomena in everyday life. The objectives of this research are: (1) to develop and produce chemistry learning media products in the form of integrated modules based on socio-scientific issues on electrolysis cell material and (2) to test the feasibility and validity of chemistry learning media products in the form of integrated modules based on socio-scientific issues on electrolysis cell material

2. Material and Methods

2.1 Type of Research

The research conducted used the type of research and development. This research and development is designed to produce learning media products as integrated modules based on socio-scientific issues enriched with augmented reality on electrolysis cell material. The research and development model used is 3-D, adopted from the 4-D development model proposed by Thiagrajan et al. [21]. The model consists of 4 stages: defining, designing, developing, and disseminating. However, the dissemination stage was not carried out due to the limited time of the researchers. The research and development procedure in this model is presented in Figure 1.

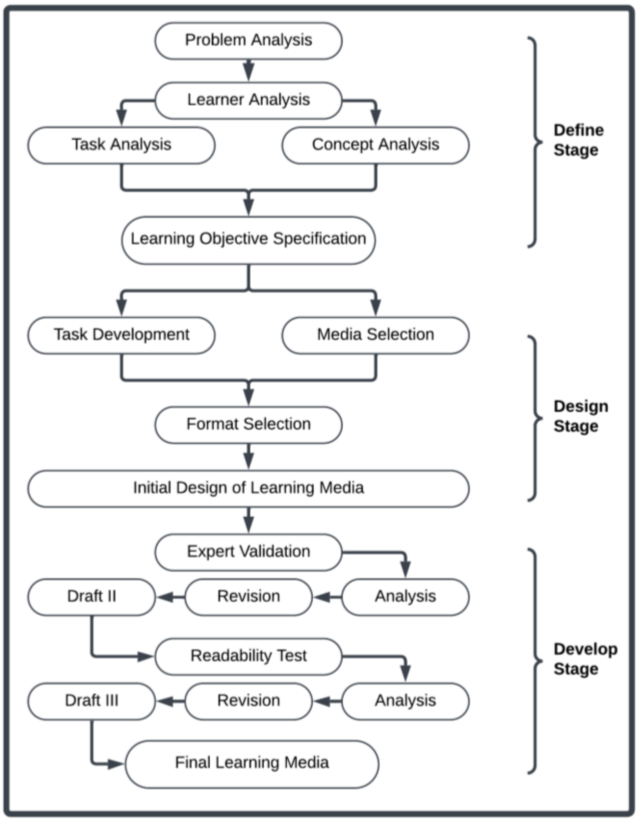

Fig. 1. Chart of Research Method Stages

A. Define Stage

Chart of Research MethoAt this stage, there are five stages: preliminary analysis, learner analysis, concept analysis, task analysis, and learning objectives analysis. Preliminary analysis aims to analyze the learning media needs of educators in carrying out chemistry learning activities in the classroom by the 2013 curriculum. Based on this analysis, learning media is needed on electrolysis cell material relevant to the 2013 curriculum, which requires student activeness in learning and utilizing technology.

Learner analysis aims to identify the elevation of learner characteristics with the learning media development design to be developed. Based on the analysis conducted, information is obtained that most students are passive when following the chemistry learning process; this is because, in chemistry learning, most educators use learning media that are less able to motivate students, so that learning media are needed that can increase student motivation, where one of them is by using learning media that contains many illustrations of images in the learning content so that students can be interested in using the learning media. Furthermore, task analysis is carried out to identify the main tasks that will be given and need to be mastered by students on learning materials. From the Core Competencies (KI) and Basic Competencies (KD) analysis, electrolysis cell material is located in KI 3 and KI 4, with KD 3.6 and KD 4.6, where KI and KD are located in class XII SMA odd semester.

The concept analysis stage examines the material's content on the learning media to be developed. Based on the identification results, the electrolysis cell material concept map is divided into three: 1) electrolysis cell components, 2) quantitative aspects, and 3) practical application in daily life. The last stage is the analysis of learning objectives; this analysis aims to determine the indicators of learning achievement of electrolysis cell material by KD in Curriculum 2013. From the results of this analysis, seven learning objectives were obtained, including 1) Students can explain the meaning of electrolysis cells. 2) Learners can explain the components of electrolysis cells. 3) Learners can explain the working principle of an electrolysis cell. 4) Learners can explain the reaction conditions in an electrolysis cell. 5) Learners can explain Faraday's law related to electrolysis cells. 6) Learners can explain the application of electrolysis cells in everyday life. 7) Learners can relate electrolysis cell concepts to SSI-based problem-solving and improve critical thinking skills. Based on this analysis, the learning media integrated module application based on socio-scientific issues enriched with augmented reality on electrolysis cell material was chosen.

B. Design Stage

At this stage, the design of learning media is carried out. The design stage begins with determining the media-making schedule to facilitate the learning media development process. Furthermore, researchers determine the specifications of the learning media to be developed and adjusted to the results of the preliminary stage, namely demanding the activeness of students in learning and utilizing technology. Then, the researchers made flowcharts and storyboards to develop modules and Android-based applications.

A flowchart depicts a chart in the form of a work explanation stage of the product to be developed. At the same time, the storyboard is a form of media to help visualize the product to be developed, which consists of appearance and layout.

Researchers designed the content of learning media. The selection of electrolysis cell material is based on a questionnaire survey of learning media needs to class XII students, literature studies, and the results of interviews with chemistry teachers SMAN 2 Batu. Based on the research, I need help understanding the electrolysis cell material, especially in discussing submicroscopic material and implementation in daily life.

C. Develop Stage

At this stage, it is carried out to produce socio-scientific-based application-integrated module products enriched with augmented reality. Researchers consulted with the supervisor of the learning media that had been made; then, it would be validated by material and media experts. After the validator gives the product validation, the researcher revises the learning media from the suggestions, comments, and input the validator gives so that the expert considers the product feasible. Furthermore, the product was tested on chemistry students in class 2022, totaling 29 students, assuming theyhad taken the subject while sitting in class XII, which is the high school equivalent.

2.2 Data Type

The types of data obtained in this study are quantitative and qualitative data. Qualitative data is in the form of suggestions and responses from validators and students, while quantitative data is in the form of a questionnaire, which is analyzed by the average analysis technique.

2.3 Data Collection Instruments

The data collection instruments in this study were material and media validation questionnaires and readability test questionnaires. The questionnaire instrument used has a scale of 1-5 (Likert scale) [19]. The questionnaire instrument aims to test the feasibility of the product from the aspects of media, material, and readability tests. The questionnaire contains questions about the product, an assessment column, and a column of responses and suggestions. Information on the Likert scale can be seen in the table below.

Table 1. Likert Scale Score Criteria [19]

Criteria	Score Criteria
Strongly Agree	5
Agree	4
Undecided	3
Disagree	2
Strongly Disagree	1

2.4 Data Anaylisis Techiques

The average analysis technique is a technique used to analyze quantitative data. This technique calculates, the score value given by validators and students with a value conversion from a 0-100 scale. The following is the questionnaire calculation formula.

$P = \frac{\Sigma x}{\Sigma x_m} \times 100$ Description: P = Percentage of feasibility.
Σx = Total number of validator / learner assessment scores.
Σx_m = Total maximum validation score

The results obtained after calculating the above formula are used to determine the validity and feasibility of the product. The level of validity or feasibility criteria used in this study is as follows.

Table 2. Criteria for Validity [18].

Percentage	Feasibility
81-100	Very feasible
61-80	Feasible
41-60	Moderately feasible
21-40	Less feasible
0-20	Not feasible

If the percentage of results ≥ 61 is obtained, then the developed product is feasible or valid to be used as a learning media in teaching and learning activities at school or home. If the percentage of results ≤ 60 is obtained, then the product developed needs to be revised again.

3. Results and Discussion

3.1 Learning Media Product Description

The development results in this study, namely learning media integrated module applications based on socio-scientific issues enriched augmented reality on electrolysis cell material for high school students as a medium to support chemistry learning. The final product of the learning media developed is a module and application that contains the basic concepts of electrolysis cells. The basic concepts of electrolysis cells contained in the learning media are: 1) understanding of electrolysis cells, 2) components of electrolysis cells, 3) working principles of electrolysis cells, 4) reaction conditions in electrolysis cells, 5) Faraday's laws I and II, 6) application of electrolysis cells in everyday life, 7) SSI-based questions about electrolysis cells, and 8) practice questions in each learning activity and evaluation questions.

The module product is divided into three parts, namely: opening, content, and closing. The opening section consists of: 1) module cover (inner front cover, outer front cover, and back cover), 2) table of contents, 3) instructions for using the module, 4) concept map, 5) identity, 6) Apsis application information. Then the content section consists of: 1) introduction, 2) material explanation, 3) practice material questions, 4) SSI-based questions, 5) material summary, 6) evaluation questions. Furthermore, the last, namely the closing section consists of: 1) scoring instructions for evaluation questions, 2) answer keys and discussion of exercise questions, 3) answer keys for evaluation questions, 4) glossary, 5) bibliography, and 6) author's biography.

The front cover is divided into two, namely, the outside and the inside. The outer front cover contains the UM logo, an illustration of an electrolysis cell, a module title, and the author's identity. While the inside has almost the same information as the front cover, there is an addition, namely the identity of the module owner. The back cover contains brief information about the module, its advantages, the author's identity, and information on accessing the Apsis application via Google Drive. The module cover is presented in Figure 2.

(a) **(b)** **(c)**

Fig. 2. (a) Outside front cover, (b) Inside front cover, (c) Back cover.

The instructions for using the module contain the flow of stages of using the module; these instructions aim to give students a practical learning experience and obtain maximum learning results in learning electrolysis cell material when using this module. Furthermore, a concept map contains an image of the concept chart of electrolysis cell material. On this concept map, the electrolysis cell material is divided into three: 1) electrolysis cell components, 2) quantitative aspects, and 3) application of electrolysis cells in everyday life. The concept of material on the concept map will be described in the form of learning materials on the core page. The identity section contains essential competencies, learning objectives, and a brief material description. Then, the Apsis application information section contains brief information about the device's specifications that can be used to operate the application. In this section, a QR barcode also functions to access the application integrated into the module. The initial part of the module is presented in Figure 3.

Fig. 3. (a) Module Instructions for Use, (b) Electrolysis Cell Concept Map, (c) Identity, (d) APSIS Application Information.

The core of the module consists of two learning activities. Each learning activity begins with the presentation of learning objectives and an introduction. The introduction contains apperception before entering the core material. In this case, the phenomenon of everyday life is used (in learning activity 1) which discusses the phenomenon of recharging batteries and Faraday's law (in learning activity 2) which discusses scientist Michael Faraday's research on electrolysis. In each learning activity, the explanation of the material is equipped with supporting images and practice questions. The core part of the module is presented in Figure 4. In learning activity 2, in the sub-section of application in daily life, there are two marker images. Markers are 2D object markers that have a pattern and will be read into augmented reality when scanned through the camera found in the AR scan feature in the application. At marker 1, if the marker is scanned, it will display an augmented reality of the application of electrolysis to the coating of iron forks using $AuCl_3$ solution with carbon electrodes. Furthermore, marker 2, if scanned, will display an augmented reality of electrolysis of copper metal refining $CuSO_4$ solution with pure and impure copper electrodes. The markers on the module are presented in Figure 5.

Fig. 4. (a) Learning Activity 1 (b) Learning Activity 2.

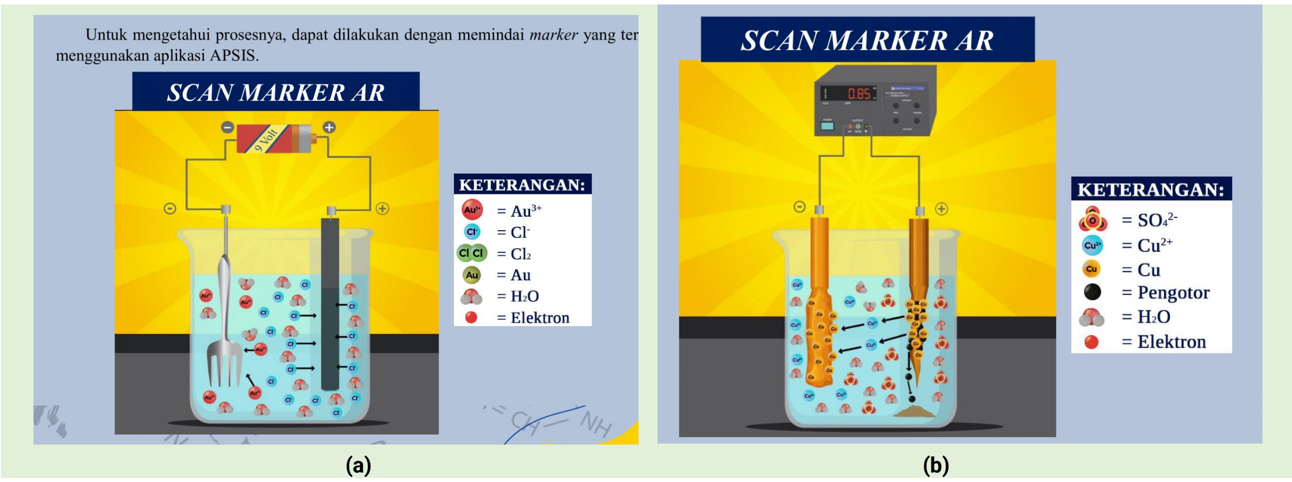

Fig. 5. (a) Metal Plating Marker (b) Metal Refining Marker.

Furthermore, after the presentation of material in learning activities 1 and 2, there are socio-scientific issues-based articles and questions. The articles in the module contain daily life phenomena related to electrolysis cell material. The first article discusses the phenomenon of coins coated with other elements, the second discusses alkaline water production with the principle of electrolysis cells, and the third discusses the phenomenon of traffic accidents on motorcycles due to rust on the surface of vehicle parts. After the articles are presented, some questions relate the phenomena discussed to the electrolysis cell material. The socio-scientific issues-based articles and questions are presented in Figure 6.

The developed module product is integrated with an application equipped with augmented reality features. The application displays augmented reality results from scanning markers contained in the module. AR marker scan results will appear right above the marker on the module. Augmented reality can help students visualize the concept of electrolysis cells to better understand them than only 2D images. The initial display when opening the application (splash screen) will display an opening display containing six main menus: AR Scan, Guide, Material, About, Exercise, and Exit. In the opening view, there is also a point button that functions to see the value of the results of working on exercise questions 1 and 2, SSI, and evaluation questions. In addition, there is also a button to adjust the height of the application's background by shifting the white circle object to the right (to increase the sound) and to the left (to decrease the sound). Then, if you want to turn off the application background, the user can direct the white circle object to the far left. The initial display of the application is presented in Figure 7.

Fig. 6. Socio-Scientific Issues article and question.

Fig. 7. App Home View.

Fig. 8. (a) Exercise & Evaluation Menu Display, (b) Exercise 1 Display, (c) Exercise 2 Display, (d) Evaluation Display.

The guide menu contains instructions for using the application. Furthermore, the About menu contains a bibliography and application developer information, and the exercise menu consists of three submenus: exercise 1, exercise 2, and evaluation. The submenu contains questions related to electrolysis cell material. In exercise 1 and exercise 2 submenus, there are markers of correct and incorrect answers accompanied by increasing or fixed points, and the application display will automatically display a discussion of the correct answer. In the evaluation submenu, only correct and incorrect answer markers are accompanied by increasing or fixed points. In this submenu, there needs to be a discussion of answers. The exit menu functions to close the Apsis application. The exercise menu displayed in the application is presented in Figure 8.

The material in the application has the same content as the module; it is intended that if students do not bring the module, then they can access learning materials through the application. In the application menu, there are nine submenus, including essential competencies, introduction and understanding, electrolysis cell components, working principles of electrolysis cells, determination of electrolysis cell reactions, Faraday's laws I and II, application of electrolysis in life, and socio-scientific issues. The material menu display is presented in Figure 9.

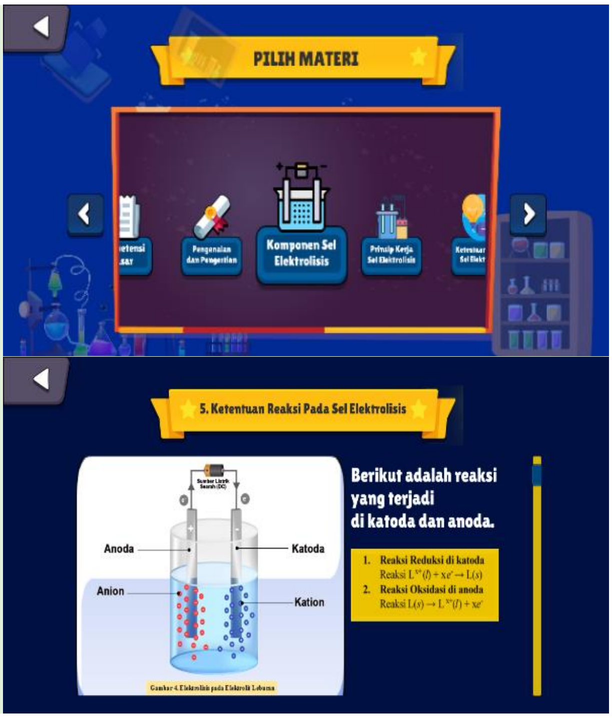

Fig. 9. Material Menu Display

The AR scan menu displays AR marker scan results on the module. When selecting the menu, the application will display two submenus, AR 1 and AR 2. AR 1 displays AR on fork plating from iron using $AuCl_3$ solution with carbon electrodes. In contrast, AR 2 displays AR from the electrolysis of copper metal purification $CuSO_4$ solution with pure and impure copper electrodes. The AR menu display and AR usage are presented in Figure 10.

The advantages of this learning media are that there are two types of learning media in the form of integrated modules and applications. With the application, students can be helped to learn and understand the material because this type of media can be used anytime and anywhere. This learning media is enriched with augmented reality; the availability of augmented reality in the media is new and exciting for students to learn electrolysis cell material because AR media still needs to be widely developed in electrolysis cell material. In the module, some markers can be scanned through the application and display augmented reality of metal plating and refining that can describe submicroscopic aspects. In addition, augmented reality can be used for experimental activities regarding applying the electrolysis cell concept in everyday life if the experiment cannot be carried out due to the unavailability of tools and materials in the laboratory or online learning. The learning media is equipped with practice questions in each learning activity, articles on socio-scientific issues, and evaluation questions with answer keys and discussions. This enables students to independently evaluate their understanding of the electrolysis cell concept they have obtained and can test their ability to link the concept of electrolysis cells with socio-scientific issues surrounding them after learning using learning media.

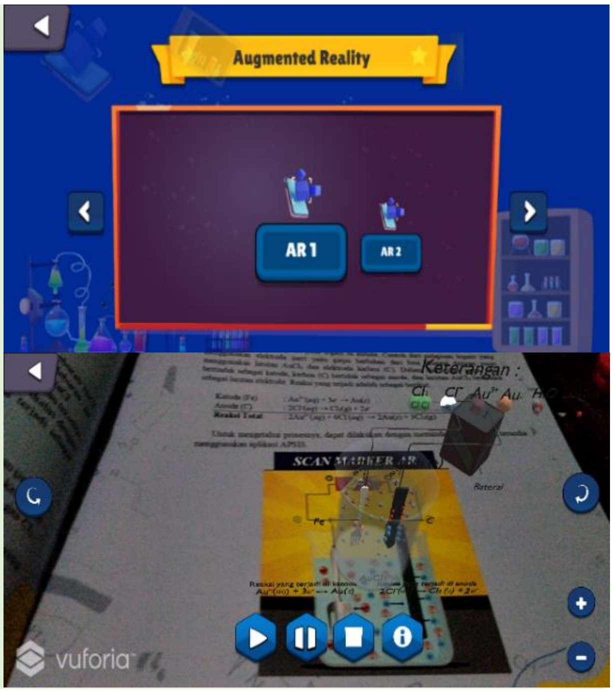

Fig. 10. (a) AR Scan Menu Display (b) AR Display in Use.

The weaknesses of this learning media include the following: the application developed only supports devices that use the Android operating system with a minimum version of 4.1 jellybeans, the application has not been developed in other operating systems such as iOS (apple device operating system), and Windows phone. In some parts of the application's text, the display could be neater because, in development, the application does not have left-right alignment, so the text content available only uses left alignment. Also, socio-scientific questions in the application are only developed in the form of multiple choice questions, yet to be developed in the form of essays.

3.2 Learning Material Validation Results

The validated learning material is electrolysis cell material. Researchers tested the feasibility (validity) of learning materials that have been developed by two material expert validators, namely one lecturer of the Chemistry Department FMIPA State University of Malang (as validator 1) and one chemistry teacher SMAN 2 Batu (as validator 2). The results of the expert validator assessment show that the assessment of the two expert validators for electrolysis cell material is very feasible, including aspects of content feasibility, presentation feasibility, language feasibility, material feasibility, and material usefulness. The description of the assessment is presented in Table 3.

The two validators had no suggestions or responses in the material validation. Then, from the validation that has been done, the average validity value of the material aspect is 98.24%. Based on this assessment, the electrolysis cell material on the learning media developed has included media with very feasible criteria.

3.3 Learning Media Validation Results

Furthermore, the feasibility of learning media developed by two expert validators was tested. In this test, several aspects are validated, including graphics, presentation, and the use of augmented reality. The validators' assessment of the developed learning media is presented in Table 4.

Table 1. Learning Material Validation Results

Assessment Aspect	Validator Average Value (%)		Total Mean (%)	Criteria
	I	II		
Content Appropriateness	90	100	95	Very feasible
Presentation Appropriateness	100	100	100	Very feasible
Language Appropriateness	100	96.67	98.34	Very feasible
Material Correctness Aspect	99	100	99.5	Very feasible
Material Usefulness Aspect	100	96.7	98.34	Very feasible
Overall Average Score			**98.24**	**Very feasible**

Table 2. Learning Media Validation Results

Assessment Aspect	Validator Average Value (%)		Total Mean (%)	Kriteria
	I	II		
Graphic Aspect	92	95.45	95.45	Very feasible
Presentation Aspect	100	100	95	Very feasible
Augmented Reality Usage Aspect	100	100	100	Very feasible
Overall Average Score			**96.81**	**Very feasible**

Based on the learning media validation results table, the learning media developed obtained an average score of 96.81%. This value indicates that the learning media is included in the feasible criteria. Apart from the validator's assessment on a Likert scale, there are also suggestions and responses given by the validator. The suggestions and responses from the validator to the learning media are presented in Table 5.

The responses and suggestions given by the validators will be followed up by making revisions to the learning media. Then, proceed to conduct a readability test for students.

Table 3. Results of Feedback and Suggestions from Validators

Aspect	Feedback and Suggestions		Improvements
	Validator 1	Validator 2	
Graphics	Customized font display in the app visually	-	In the application, the font display has been visually adjusted, with details on the content in general, the font size is reduced, and the font on the answer choices for SSI questions is enlarged.

3.4 Readability Test Results

After validating the media and material to the validator, they then continued the readability test of the learning media to 29 undergraduate students of Chemistry Education, Offering B, semester 2, State University of Malang. This research subject is selected based on the fact that these students have taken electrolysis cell material while sitting in class XII SMA. In the readability test, students were directed to read and understand the instructions for the learning media developed (applications and modules). Furthermore, learners are asked to download the APSIS application via the QR barcode on the Apsis application information page. Then, learners are directed to examine the material available on the learning media. After that, students are directed to use augmented reality contained in the learning media by scanning the markers available in the module using the AR scan menu in the application. In the last step, students are directed to fill out a readability test questionnaire on a Likert scale and also provide suggestions and responses to the learning media. Data from the small group trial results are presented in Table 6.

Based on the data in Table 6, the overall average group readability test result is 91.77%. This value indicates that the learning media developed has met the very feasible criteria. This feasibility also illustrates that students can obtain information well after using learning media. Learners also provided suggestions and responses to the learning media. The following suggestions and responses from students include: A) Discussion of exercise questions should be made in videos so that users can more easily understand how to solve these questions. B) Applications for learning media can be developed in the iOS system. C) The augmented reality section of the application can be given additional explanation features in the form of audio. Suggestions given by students will be considered in making further revisions to improve the quality of the learning media developed.

Table 4. Readability Test Results.

Aspects Assessed	Value (Percentage)	Criteria
The overall design of the learning media is attractive	96,55	Very feasible
Instructions for use contained in the learning media are easy to understand	95,17	Very feasible
The concept map contained in the learning media is easy to understand	91,03	Very feasible
Learning objectives in this media are easy to understand	95,17	Very feasible
The language used in the learning media is easy to understand	92,41	Very feasible
The text contained in the learning media can be read clearly	95,86	Very feasible
The placement of pictures and tables in the learning media is precise (appropriate)	93,79	Very feasible
The material presented in the media is easy to understand	91,03	Very feasible
3D animation videos presented in markers and learning media are clear	86,21	Very feasible
Marker scanner scan markers are easy to operate	82,76	Very feasible
The availability of a glossary makes it easy for you to understand the terms you in the media need help understanding.	93,79	Very feasible
Questions on practice questions, SSI questions, and evaluation questions are easy to do	84,14	Very feasible
The answer keys to the exercise questions, SSI questions, and evaluation questions are straightforward (easy to match with the activities in the learning media)	93,79	Very feasible
This learning media increases my motivation to learn electrolysis cell material.	93,79	Very feasible
This learning media is easy to access and use anytime and anywhere.	91,03	Very feasible
Overall average	**91,77**	**Very feasible**

4. Conclusions

The products produced from the results of this study are in the form of learning media integrated module applications based on socio-scientific issues enriched with augmented reality on electrolysis cell material. This media contains the basic concepts of electrolysis cells consisting of an understanding of electrolysis cells, electrolysis cell components, working principles of electrolysis cells, reaction conditions in electrolysis cells, quantitative aspects of electrolysis cells, application of electrolysis in everyday life, and equipped with exercise questions, evaluation questions, and socio-scientific issues-based questions. Based on the validation data analysis results, the learning media developed obtained an average material validity of 98.24% and an average media validity of 96.81%. The readability test results obtained an average validity of 91.77%. This shows that the learning media developed has very feasible product quality.

Based on the research and development that has been done, the use of learning media-integrated socio-scientific issues-based applications enriched with augmented reality on electrolysis cell material is highly recommended for use in chemistry learning activities. This media can be a variation in learning electrolysis cell material. However, this media also has several shortcomings: the application developed only supports devices with the Android operating system with a minimum version of Android 4.1 jellybean. It requires an ample internal storage of 700 Mb. In addition, the application needs to support devices operating on the iOS system and Windows phones. Then, regarding the neatness of text content, the application still needs to be neater. It still needs to be equipped with AR explanations in the form of audio. So that further improvements and developments are needed in the following research. The learning media integrated module application based on socio-scientific issues enriched with augmented reality on electrolysis cell material can be continued to the dissemination stage in order to determine the effectiveness of improving critical thinking skills and learning outcomes, as well as student motivation after using Apsis learning media.

Author Contributions

Dhimas Bagus Kurniawan has develop the concept of the research, giving visualization, investigating, and perform formal analyisis. Dhimas Bagus Kurniawan also become the weiter of original draft. Sumari also become supervision of this research and review and editing the final draft.

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