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Development of Science E-module Based on Augmented Reality Using Assembler Edu on the Material of Substances and Their Changes

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Abstract. Students' understanding of abstract concepts in the material on substances and their changes is still a challenge in science learning. This study aims to develop a valid and practical augmented reality-assisted science module using assembler edu on the material of substances and their changes. this type of research is research and development (r&d) and uses the ADDIE development model. The procedures of this study include (1) the analysis stage, (2) the design stage, (3) the development stage. The data collection instruments used were a needs questionnaire, a validation questionnaire for material and media experts, a questionnaire on the practicality of teachers and students. The subjects in this study included validation test subjects consisting of 3 material experts and 3 media experts, a practicality test consisting of 3 science teachers and 30 students. The implementation of the practicality test was carried out at SMP Negeri 40 Pekanbaru in the 2024/2025 Academic Year. The results of the study show that: 1) based on the results of the validation test by material experts and media experts, the assessment scores were 0.99 and 0.97 with very valid qualifications, (2) based on the results of the practicality test by practitioners/teachers and students, the average scores were 3.75 and 3.70 with very practical qualifications. Based on the results of the validation and practicality tests, the science module assisted by augmented reality on the material of substances and their changes is declared valid and practical to be used as teaching materials in the learning process.
Keywords: ADDIE, Augmented Reality, Assembler edu, E-Modul

Introduction

Education is a vital foundation in the formation of individuals and a thriving society. Along with technological advances, learning approaches have also evolved to accommodate changing times (Maskur et al., 2020). The era of revolution 4.0 is marked by the rapid

development of the internet and digital technology, causing everything to become limitless (Hastuti et al., 2022). The era of revolution 4.0 is believed to have an impact on changes in many fields, including science learning, thus giving rise to many challenges that arise in learning (Tzortzoglou et al., 2023).

Current learning must refer to the four characteristics of 21st century learning, namely critical thinking and problem solving, creativity and innovation, collaboration, and communication (Zorlu, 2021). 21st century learning requires open and adaptive learning to current technological developments (Vari & Bramastia, 2021). The development of digital technology has changed many aspects of daily life, including education (Jibril, 2023). The younger generation is growing up in an environment that is colored by technology, with easy access to digital devices such as smartphones, tablets, and computers. The challenge for education is how to integrate this technology into the learning process to remain relevant and effective (Maritsa et al., 2021). To overcome these problems, technology-based teaching materials are needed.

E-module is a module in electronic format that is run by a computer. E-module can display text, images, animations and videos (Agussalim et al., 2021). The use of technology in the learning process and learning resources can help students learn abstract science concepts easily and interestingly, which can be used for independent learning with a self-instructional nature (Dewi, 2023). One of the technologies that will be linked to the e-module is AR (Oktaviyanti, 2023). AR is a technology that allows users to see the real world with the addition of digital elements displayed interactively through electronic devices (Pujiastuti & Haryadi, 2023).

Current technological developments have given birth to software that carries the theme of AR. This software is very suitable for the needs of students because this software presents a 3D image display. One of the programs that carries AR is the assembler EDU software (Lino, *et al* 2022). This software can be downloaded for free on the play store and app store. Putri, (2024) called it that "This platform is a combination of Lego and Pokemon GO. Assemblr is designed to help users create 3D content that is visualized into augmented reality. The results can be placed in the real world for everyone to access.

In an educational context, AR offers an immersive and interactive learning experience, which can increase student engagement and facilitate the understanding of abstract concepts (Fauzi et al., 2021). Augmented reality has three main characteristics: a combination of real-world and virtual elements, interaction with the user in real time, and registration in 3D space (Yildiz, 2022). AR displays objects and concepts in different ways and at different angles, which helps students understand the subject better (Saidin et al., 2024). E-modules that have been used in the learning process still have a simple layout and contents that only consist of basic materials. This certainly, in addition to reducing students' interest in reading, has not provided additional knowledge about various applications in everyday life related to the material. An attractive module with a layout and content that provides additional knowledge and can be visualized in real form (3D) in addition to displaying learning materials will provide its own motivation for students to read books or science learning modules on the material of substances and their changes.

AR technology can create interactive and fun learning experiences by illustrating scientific concepts visually and dynamically, improving student understanding (Maryam et al., 2020). AR also increases students' motivation to learn with an engaging experience, helping them become more motivated in learning science. In this digital age, understanding science and being able to adapt to new technologies is key. The use of AR in science learning helps prepare students for future challenges where technology plays an increasingly important role (Atalay, 2022).

The main factor in learning science is that students learn through an inquiry process so that they can learn with good enthusiasm and comfortable conditions (Sari et al., 2021). Inquiry education facilitates students in the development of skills and performance, which

indirectly guides them in the way they learn, teaching them to always strive to improve reasoning and creativity in the process of holistic personal development (Linda et al. 2021). The use of augmented reality requires learning activities that are able to involve students in scientific thinking and experience in finding out the answers to existing questions themselves (Rahmat et al., 2023). When information is taught through interesting images or videos, students tend to be more engaged in learning. The use of audio-visual media can increase learning activities in the classroom (Syafruddin et al., 2024).

The use of augmented reality technology in schools with limited technological infrastructure is very urgent to improve the quality of education in remote areas. Ar is able to overcome various obstacles, such as lack of laboratory facilities, lack of open books, and limitations of other learning aids. With this technology, students can learn abstract concepts through interactive visualizations that are more interesting and easy to understand, without even requiring expensive physical facilities (Zaky et al., 2024). Additionally, ar can help teachers deliver material more effectively, even with simple devices and limited internet access, because many ar modules can be designed to operate offline. This technology also plays a role in building technological literacy among students and teachers, providing relevant provisions to face challenges in the digital era. By implementing ar, the education gap between urban and rural areas can be minimized, thereby supporting the creation of equal access to quality education (Nadjamuddin et al., 2024).

The formulation of the problem to be studied in this study is how to develop an AR-based science e-module, its validity, and its practicality. One of the urgencies of the problem is related to science education, which is currently very important in Indonesia, especially with the use of AR. The purpose of developing an e-module is to describe the development process and evaluate the validity and practicality of an augmented reality-based science e-module using assembler edu on the material of substances and their changes to improve students' critical thinking skills.

Methods

This research uses the research and development method, often called R&D, which is a research method used to produce certain products and test the effectiveness of the products made (Sugiyono, 2008). The research and development model used to develop the augmented reality-assisted science e-module on the material of substance and its changes is the ADDIE model. The stages in the ADDIE model in this study are incomplete, where only the analysis, design, development, and evaluation stages are carried out, without the implementation stage. In this study, implementation was not carried out because the purpose of this study was to produce an AR-assisted science e-module on the material of substance and its changes. So it can be said that the researcher used a modified ADDIE method.

The data collected in this study were descriptive qualitative data. In this study, data collection techniques included descriptive qualitative data obtained from responses or e-science modules assisted by AR on the material of substances and their changes. The e-modules developed in this study were assessed for their characteristics, validity, and practicality. This research was conducted at SMP Negeri 40 Pekanbaru. The object of this study used the science module assisted by AR on the material of substances and their changes. The subjects in this study consisted of material experts, media experts, teachers, and students. The assessment aspects in the validation questionnaire of material experts, media experts, teachers, and students used the same score with the following assessment criteria.

Table 1. Likert Scale Assessment Categories

Likert Scale	Assessment Category	Information
4	Strongly Agree	SS
3	Agree	S
2	Disagree	TS
1	Strongly Disagree	STS

Source: (Sugiyono, 2019)

Each assessment indicator on the validation sheet is declared valid if it has a value of ≥ 3. If there is an indicator that has a value of <3, then improvements or revisions need to be made to each product according to the suggestions or input on the validation sheet. The indicators in question (Isnaini et al., 2022).

According to (An Nabil et al., 2022) To determine the validity value calculated using the following Aiken V formula:

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

V = Validity Score

s = The score given by the assessor minus the lowest score in the category

c = Highest Rating Score

n = Number of Validators

The data obtained using the Aiken V formula was then interpreted descriptively based on Table

Table 2. Interpretation of Aiken's V Coefficient

Average score interval	Criteria
0.80 < r ≤ 1.00	Very High
0.60 < r ≤ 0.80	High
0.40 < r ≤ 0.60	Fair
0.20 < r ≤ 0.40	Low
0.00 < r ≤ 0.20	Very Low

Source: (Azwar, 2012)

The data from the practicality test results of the augmented reality-based science e-module on the material of substances and their changes were analyzed by looking at the qualitative assessment criteria for each aspect containing several indicators. The qualitative data that has been obtained is converted into quantitative data and presented on a Likert scale, namely 1-4 (Yulianti, et al., 2023) The practicality value is obtained by using the following formula:

$$\text{Practicality} = \frac{\text{Total score}}{\text{Maximum score}} \times 100$$

The practicality criteria of teachers and students towards the augmented reality-based science e-module are made with a score range of 1 to 4. The average score is interpreted based on the practicality criteria of the e-module. The practicality criteria carried out on teachers and students can be seen in Table 3.

Table 3. Practicality Criteria for AR-based science e-modules

Average score interval	Criteria
>3.25 – 4.00	Very practical
>2.5 – ≤ 3.25	Practical
>1.75 – ≤ 2.5	Less practical
1≤ 1.75	Not practical

(Source: Arikunto, 2021)

Results and Discussion

The development research conducted resulted in a product in the form of an augmented reality-based science e-module using assembler edu on the material of substances and their changes, which can be accessed via iOS or Android smartphones.

Results of module needs analysis

The results of the needs analysis on the use of science e-modules obtained through the distribution of questionnaires to 3 science teachers and 36 junior high school students in Pekanbaru City showed that most teachers (66.6%) had used teaching materials in the learning process. Of the teaching materials used, printed books were the most dominant with a percentage of 42.4%. In addition, the use of technology media by teachers has also begun to be seen, with powerpoint used by 33.3% of teachers and learning videos by 24.3% of teachers. However, the use of AR technology in learning activities has not been implemented at all, as evidenced by the percentage of 0%. Some teachers have created their own technology media, such as PowerPoint, while others have downloaded learning videos from the internet. Although teachers receive training in creating technology media, not all teachers have the opportunity to participate in the training. As a result, the use of technology media in learning is felt to have not fully helped students learn independently and understand abstract material concepts. This shows the need to develop more interactive learning media, such as AR-based e-modules, to support students' understanding of concepts that are difficult to visualize.

Table 4. Results of module needs analysis

No	Question	Answer Options	Module needs (%)
	Teacher Needs Analysis Results		
1	Teachers use teaching materials in teaching and learning activities	Yes	66.6
		No	33.4
2	Learning media that are often used when teaching science learning materials	Powerpoint	33.3
		Printed books	42.4
		Vidio	24.3
3	Teachers integrate the development of science and technology in creating science learning media	Yes	66.7
		No	33.3
4	Teachers create science learning media to support students' science and technology development	Ever	66.7
		Never	33.3
5	What types of modules do teachers use in science learning?	Print module	66.7
		Electronic module	33.3
6	How do teachers obtain technology media	Make your own	54.4
		Provided by school	3.1
		Download from the internet	42.5
7	Teachers have integrated Augmented Reality technology into the science learning process	Yes	66.7
		No	33.3
8	Science modules assisted by AR are interesting technology media	Yes	100
		No	0
9	The need to use Science Modules assisted by AR	Yes	100
		No	0

Student needs analysis results			
1	Learning media that is often used in teaching and learning activities	Ppt Buku cetak Vidio Lainnya	25.7 57.1 11.4 5.8
2	Students are happy if science learning uses interactive technology-based learning media	Yes No	97.1 2.9
3	Students have studied science using AR technology	Ever Never	62.9 37.1
4	The use of AR in science learning helps understand difficult concepts	Yes No	80 20
5	The science module assisted by AR is an interesting technology media	Yes No	100 0
6	The need to use science modules assisted by AR in teaching and learning activities	Yes No	100 0

Based on the analysis results in the table above, it was found that teachers are still lacking in utilizing media that support science learning. In fact, learning media is very important to be created and used by teachers in delivering science learning. The difficulty of students in understanding the material on substances and their changes is partly due to the lack of utilization of supporting learning media as a learning resource (Rahmat et al., 2020).

This is supported by a study Dewi (2020) that found that teachers only use learning media in the form of thematic books provided by the government, so that students easily get bored and cause students to be inactive during learning activities. To overcome this problem, teachers should be able to develop active, innovative, and interactive learning media, especially in the process of delivering science learning (Fitriasih, 2023). The use of media in learning helps to increase the effectiveness of the delivery process to students because the information is presented in an interesting way. Interactive learning media fosters meaningful involvement between students and the media while providing reciprocal action (Wahyuni et al., 2022).

Design Results

The science module design process begins with the preparation of the material concept, then continues with the module display components and applications. The results of the module component display design can be seen in the Table 5.

Table 5. Module components

Module components	
Beginning	Front cover, foreword, table of contents, e-module learning instructions, augmented reality usage instructions, concept map, content standards (learning outcomes and learning objectives)
Content	Introduction, apperception, material, lkpd, quiz game, summary and competency test
End	Evaluation, glossary, bibliography, answer key, and author biodata

The design stage of the science e-module is carried out based on data obtained from the results of the needs analysis. The design process begins with collecting concepts, followed by making an initial design of the module and application display, which includes selecting the media, format, and fonts to be used. The next step is making a storyboard, which is compiled using microsoft word 2019. At this design stage, an instrument in the

form of a questionnaire is also prepared for validation tests by material experts, media experts, and practicality tests. The developed e-module includes in-depth and detailed learning materials and is equipped with 3D image animations to make it easier for students to understand the concept of substances and their changes, which are abstract. The use of this animation aims to increase students' motivation and interest in learning, in line with the statement Wulandari et al. (2023) which states that the use of media or images in the learning process can arouse desires, new interests, and motivate students, and even provide positive psychological impacts.

Development Results

The science e-module that has been designed at the design stage is then finalized based on the suggestions and assessments of the validator. The E-module that has been prepared is then continued with validation activities carried out by experts. Validation was carried out by 3 media experts, 3 of whom were lecturers in informatics engineering at Sultan Syarif Kasim State Islamic University, Riau, and 3 material experts: 1 chemistry lecturer at Riau University, 1 chemistry lecturer at Sultan Syarif Kasim State Islamic University, Riau, and 1 chemistry lecturer at Muhammadiyah University of Riau. Validation assessment was carried out using a validation questionnaire. The results of the validation of media and materials in the e-module carried out by experts can be seen in Table 6.

Table 6. Expert validation test assessment

Validators	Validity score	Criteria
Subject matter expert	0.99	Very high (very valid)
Media expert	0.97	Very high (very valid)

Based on the results of the validation test from material experts and media experts, it shows that the science e-module based on AR on the material of substances and their changes that was developed obtained scores of 0.99 and 0.97, respectively, which meet the criteria with very valid qualifications.

Implementation results

One-on-one trials were conducted to identify students' difficulties in using the augmented reality-based science e-module, involving 5 seventh-grade students of smpn 40 pekanbaru with varying levels of ability (high, medium, low). The researcher provided a brief explanation of the module and its operation, and then the students carried out the learning independently using an android cellphone. The results of the trial showed students' enthusiasm because of this new experience, considering that they had never learned using the e-module before. A summary of the trial results is presented in Table 7.

Table 7. Results of one-on-one trial of augmented reality-based science e-modules

Aspect	Student Responses
Difficulty	1. Students with high and medium abilities are quite proficient in using the augmented reality-based science e-module to interact with the content and icons in the application. However, students with low abilities still have difficulty operating this e-module, so they need teacher guidance to understand how to navigate and use the available features. 2. Students with low abilities have difficulty answering questions in the e-module. They tend to write the answers on paper first, then transfer the answers to the e-module, which indicates the need for improved skills in direct digital interaction.

	3. All students face network-related constraints when accessing the e-module, so teachers must also be on standby regarding internet quotas.
Ease	Most students consider the augmented reality-based science e-module easy to use. This is because of the clear usage guide features, interactive step-by-step instructions, and a simple application interface. In addition, the use of qr codes to access augmented reality content and the delivery of materials in easy-to-understand language also make it easier for students to follow the learning.
Time Efficiency	The five students were able to complete the learning activities using the augmented reality-based science e-module according to the specified time. However, they still need supervision and guidance from the teacher, especially when facing questions or obstacles related to the use of features in the e-module.
Interesting	The five students enjoyed learning using the augmented reality-based science e-module because the display was attractive and interactive.

The student practicality test was conducted to measure the response to the use of AR-based science e-modules in learning by involving 30 grade VII students of SMPN in Pekanbaru. Students were grouped heterogeneously and followed learning with modules that were also displayed using an infocus. Meanwhile, the teacher practicality test involved three science teachers at SMPN Pekanbaru. Teachers used the modules provided via links, then assessed them based on indicators of interest, material, and language with 14 statement items. The results of the teacher and student practicality tests are presented in Table 8.

Table 8. Practicality test assessment by teachers and students

Validator	Practicality score	Criteria
Teacher	3.75	Very practical
Student	3.70	Very practical

After the science e-module was validated by material experts and media experts, a practicality test was carried out by teachers and students. This practicality test was carried out at SMP Negeri 40 Pekanbaru, involving science subject teachers and grade VII students. The results of the teacher's assessment showed an average score of 3.75, and students showed an average score of 3.70, which is included in the very practical category. This assessment with a very practical qualification shows that the augmented reality-based science module that was developed received a positive response and will be used in the learning process. This is in line with the opinion of Liliasari et al. (2016), which states that the use of teaching materials in learning can help students improve their understanding, present data in an interesting and reliable way, and facilitate data interpretation and information conclusions. This is also supported by research (Zaputra et al., 2021) which shows that the media developed is easy to use by teachers, easy to understand, in accordance with scientific characteristics, and can be used repeatedly, and the practical values of learning media can control and organize students' learning time to be more efficient.

The research published in this journal only covers the development stages of augmented reality based e-modules, including the design, validation, and feasibility testing processes for the modules. The implementation stage of the ar module in a real learning

environment is not the main focus in this journal but will be discussed separately and published in other journals that are more relevant to aspects of technology application in education. This is done to provide space for more focused and in depth discussion at each stage of the research.

Evaluation results

Evaluation in this research was carried out through the analysis, design, development and implementation stages. At the analysis stage, it was found that material about substances and their changes was one of the science learning materials that students considered difficult. This is in line with the findings of Yunarti, (2021), who identified that students often have difficulty understanding abstract concepts in science material. In addition, the analysis shows that students' critical thinking skills are relatively low, as stated by Muhammad et al. (2023), who emphasize the importance of developing critical thinking skills through science learning.

The validation results of the development of the augmented reality-based science e-module on the material of substances and their changes as a whole are classified as valid and suitable for use after 2 validations and improvement processes from expert validators. The level of practicality of the augmented reality-based science e-module on the material of substances and their changes is classified as practical. The response of students to the augmented reality-based science e-module on the material of substances and their changes from the development results also showed a very good positive response. The evaluation at the development and implementation stages has been discussed directly in the discussion of the sub-chapter.

Conclusion

The development of an AR-based science e-module using assembler edu on the material of substances and their changes has been proven valid and practical, offering an innovative learning tool to enhance students' understanding and engagement with abstract science concepts effectively.

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