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Original Research Article

The development of enrichment book of chemistry in our body based on augmented reality and its influence on chemistry literacy and scientific attitude of high school student

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ABSTRACT

This research aims of this research is to obtain produce enrichment book of chemistry in our body based on augmented reality which can display the 3D shape of molecular shape and chemical bonds developed from macromolecular materials that are suitable for increasing student chemical literacy and scientific attitude. This development research uses a 4D model developed by Thiagarajan which consists of stages Define, Design, Development, and Disseminate. The trial was carried out on 1 limited test class and 2 wide test classes (1 experimental class and 1 control class) of XII Science students at Senior High School of Angkasa Adisutjipto. The results of the research show that: 1) Enrichment book of chemistry in our body based on augmented reality that have been developed have very decent quality by media and materials validators; 2) the practicality response are included in the "Very Good" category with the average score of the percentage of ideals obtained of 88.62%; 3) the students response are included in the "Very Good" category with the average score of the percentage of ideals obtained in the limited trial of 81.21% and extensive trial of 84.39%; 4) the product are effective in increasing students chemical literacy and scientific attitude with the MANOVA test which obtained a significance value of 0.001; 5) the product are effective in improving students' chemical literacy with the MANOVA test which obtained a significance value of 0.006; 6) the product are effective in increasing students' scientific attitudes with the MANOVA test which obtained a significance value of 0.006.

Introduction

Some of the main problems in chemistry education are identifying learners' misconceptions and learning difficulties about chemical materials and finding solutions or effective ways to overcome them. Online learning is also a problem because it is difficult to build understanding between teachers and students. Misunderstandings experienced by students in understanding chemical properties and chemical interactions, make it one of the fundamental sources of learning difficulties (Tumay, 2016). In addition, problems that must be corrected in the learning process to improve the competence of the learning process are that teachers have difficulty in formulating basic competencies, material structure, and time allocation in the learning process (Kadariah et al., 2020).

The era of the Industrial Revolution 4.0 is the stage of knowledge development in the physical, digital, and biological domains that interact with renewable technology (Schwab, 2016). Rapid changes in knowledge require teachers to better prepare new strategies and innovations such as the development of learning resources or learning media that utilize technology (Shahroom & Hussin, 2018). This is in line with what was conveyed by the Head of the Executive Team of the National Information and Communication Technology Council at the Indonesia Edutech Expo 2020, Ilham Habibi, namely the tendency of the upcoming learning process is the use of technology as a tool to encourage student motivation and interest in learning.

Science literacy aims to construct students' knowledge by applying science concepts meaningfully, thinking critically, and making balanced decisions about problems related to students' lives (Rahayu, 2017). In fact, science education in Indonesia still does not pay attention to the socio-cultural environment that is a source of learning, thus impacting students' low science literacy (Imansari et al., 2018). In general, students tend to gain knowledge about material concepts through rote memorization without understanding the idea, this results in students having difficulty relating material to scientific concepts in real life, and learning becomes less meaningful (Wardani & Anggraeni, 2019).

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Scientific attitude is part of chemical literacy, which is one of the main objectives of chemistry education. Scientific attitude is an important goal that must be developed in the chemistry/science education field. The scientific attitude is a combination of many qualities and virtues that are reflected in a person's behavior and actions. The scientific attitude component consists of curiosity, honesty, open thinking, and being able to ask critical questions through the means of critical thinking (Zulifran, 2018).

Chemistry has complex and abstract concepts that make students consider chemistry subjects difficult (Ristiyani & Bahriah, 2016). Some students have a low interest in chemistry because most of the materials contained in chemistry are considered difficult for students to understand (Hemayanti et al., 2020). Macromolecular material is one of the materials that requires a deep understanding of concepts and needs to be studied repeatedly (Viani & Kamaludin, 2020). As many as 63.64% of students find it difficult to learn macromolecules because the material is difficult to understand and the availability of teaching materials is lacking (Winarti et al., 2019).

The difficulty often experienced by students is in finding innovative alternative learning media, as an independent learning resource to help students overcome difficulties in understanding chemical materials (Silalahi et al., 2020). Therefore, with proper supervision and direction, it is hoped that the use of innovative learning media can help the academic and non-academic scope of students to improve effective and efficient learning by emphasizing the use of technology and communication. The innovation that needs to be done in developing teaching materials to face 21st-century learning is to integrate teaching materials using technology. One form of innovation in technological development is Augmented Reality (AR). Augmented reality is a technology that displays virtual objects in the real world. Use Augmented Reality Can facilitate interaction with virtual objects in the same situation (Nordin et al., 2022).

One of the topics of chemistry education that is closely related to everyday life is macromolecular material in class XII of Senior High School Angkasa Adisutjipto which can be used to see its effect on chemical literacy and scientific attitudes of students. Therefore, research was carried out on the development of the chemistry in our body enrichment book based on augmented reality. This developed enrichment book is expected to be used as an interesting learning resource so that students are interested in learning chemistry, stimulates creativity, and curiosity of students towards chemistry and can affect chemical literacy and scientific attitudes of students. Based on the introduction above, the purpose of this development research is to determine feasibility, practicality, and readability of enrichment book of chemistry in our body based on augmented reality, as well as to improve the chemical literacy and scientific attitude of student, determine the simultaneous effective contribution of discovery learning using the enrichment book of chemistry in our body based on augmented reality to the chemical literacy and scientific attitude of students, to determine the effective contribution of discovery leaning using the enrichment book of chemistry in our body based on augmented reality to the chemical literacy of student, and to determine the effective contribution of discovery leaning using the enrichment book of chemistry in our body based on augmented reality to the scientific attitude of student.

Methods

Sample and population

The research was conducted at Angkasa Adisutjipto High School, Special Region of Yogyakarta in February - April 2024. According to Gay et al. (2009) for descriptive method research, at least 10% of the population, while for a relatively small population at least 20%. Grade XII students of high school in Sleman, Yogyakarta, which is equivalent to Angkasa Adisutjipto High School, are the population used in this study. The sample in this study is Angkasa Adisutjipto High School class XII Science. One class XII Science as a limited trial group, one class XII Science as an experimental class and one class XII Science as a control class. The experimental class and the control class do not affect each other. Sampling of the study used cluster random sampling technique.

General procedure

The research conducted is research and development (R&D). This development research aims to develop of enrichment book of chemistry in our body based on augmented reality and Its Influence on students chemical literacy skills and scientific attitudes. The 4D models developed by Thiagarajan were chosen as the basis for the development of the enrichment book. 4D models are a simple method in the process of developing a product. The research model is divided into 4 main stages, namely define, design, develop, and disseminate (Irawan et al., 2018). The 4D development stage is presented in Fig-1.

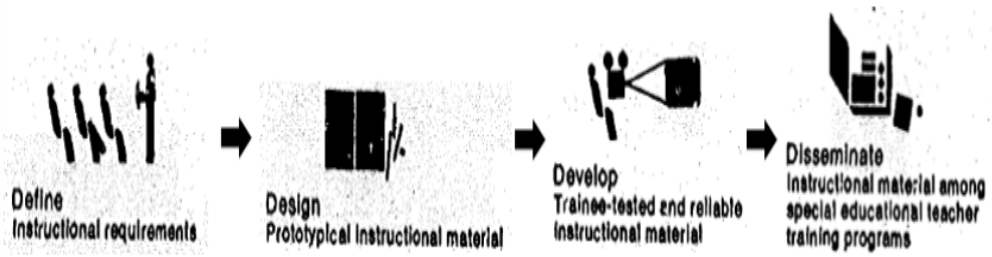

Fig-1. The 4D development model research procedure (Thiagarajan, 1974)

Define stage

The definition stage is carried out to determine and define various needs in the learning process. This stage is also useful for gathering various information related to the product being developed. The analysis is carried out through literature studies or preliminary research. The final result obtained from this define stage is a guideline for product development.

Design stage

The design stage is carried out to obtain a draft design or initial design of the product being developed. The result obtained at this design stage is the initial product draft.

Development stage

The development stage to create learning media is in the form of enrichment book of chemistry in our body based on augmented reality. In this stage, the researcher also conducts a validity/feasibility test of the product to be developed based on the results of validation by validators, namely media experts and material experts. After the validation process is carried out by expert lecturers, the next step is to revise it in accordance with the opinions and suggestions of experts.

Disseminate stage

The dissemination stage is carried out to disseminate the final product of the product that has been developed so that it can be useful to others. At this stage, the results of the development are involved in seminars or published in scientific journals.

Data collection in this study was carried out with the following techniques: (a) instrument validation sheet is used to determine the validity of the instruments that have been prepared; (b) product feasibility assessment sheet and practicality test is used to determine the feasibility of a product that has been designed at the design stage based on the assessment of experts, and chemistry teachers. This assessment sheet consists of a product feasibility assessment sheet by material and media experts, a practicality test sheet by teachers; (c) student response questionnaire is used to obtain the results of students' responses to the products developed; (d) chemical literacy question sheet is used to measure students' chemical literacy skills. This sheet contains 8 chemical literacy test questions in the form of descriptions (essay); and (e)Scientific attitude questionnaire is used to measure students' scientific attitudes during learning. The questionnaire is in the form of a student's self-assessment consisting of five components, namely, curiosity, critical thinking, open thinking, honesty, and responsibility. This questionnaire contains statement items that are prepared based on the synthesis of indicators from Scientific Attitudes.

Data analysis

The data analysis techniques used in this research are qualitative and quantitative. The instruments used in this study were all tested for validity and reliability before use. The validity used in this study is the learning instrument and the instrument of each research variable.

Results and Discussion

Development of enrichment book of chemistry in our body based on augmented reality and Its influence on chemical literacy and scientific attitudes of high school students with the research method used is research and development or Research and Development (R&D) which is carried out based on the steps of the 4D development model which consists of the stages of define, design, develop, and disseminate. The following is an explanation of the results of the initial product development that has been carried out.

Define stage

At this stage, the initial analysis, student analysis, assignment analysis, concept analysis, and learning objective analysis are carried out. The following is an explanation of each part of the define stage. In the initial analysis, interviews and observations were carried out on the learning activities carried out by teachers in schools. Based on the initial analysis, it is known that teaching materials and material presentation during online and offline learning, both teachers and students are used to learning using smartphones. The use of learning media is also quite wide, but for technology-based learning media such as Augmented Reality, according to teachers and students, it still needs to be developed more widely to add more diverse, creative and innovative ways of delivering chemistry.

Based on the results of observations and interviews that have been conducted, it is known that almost all students still lack understanding with chemistry delivery. In the teaching and learning activities in the classroom carried out by teachers, there are still many students who lack attention, daydream, joke and chat with their peers. It can be seen that there is a lack of enthusiasm of students in following the learning so that students are also less active in the learning process and are embarrassed to ask, answer, respond or express their opinions which results in the ability of students to solve problems is still very low. This shows that the low chemical literacy ability of students and students who consider chemistry as an abstract material is also still found as a common problem in chemistry learning so that it of course affects the scientific attitude of the students.

The analysis of the assignment was carried out by examining the core competencies and basic competencies to determine the content of the product developed, including several deepening of the material and indicators of student learning outcomes. Concept analysis is carried out to identify the main concepts of the product to be developed such as learning materials, clearly compiling concepts, and important concepts on macromolecular materials by utilizing technological developments in the form of Augmented Reality.

Design stage

The purpose of the planning stage is to design the learning tools to be developed so that the initial design of the learning tools (draft I learning tools) is obtained. In addition to the devices to be developed, at this planning stage the researcher also designs research instruments that will be used to support the implementation of limited trials.

The preparation of the planned research instruments consists of test and non-test instruments. The preparation of test instruments consists of a grid of chemical literacy questions. While the non-test instrument consists of a questionnaire grid. In this step, a test instrument was prepared and used to determine the chemistry literacy ability of students before and after using the product. The test questions are made in the form of pre-test essay questions and post-test essay questions. The results of the empirical test on the pre-test and post-test questions, out of a total of 16 questions tested, as many as 16 questions passed and were suitable for use in field research as seen from the reliability value of the pre-test and post-test questions, which was 0.589 which was interpreted with sufficient reliability. The reliability test results can be seen in Table 1.

Table 1. Reliability test result of chemical literacy test

Reliability Statistics	
Cronbach's Alpha	N of Items
0.589	16

Table 2. Results of the scientific attitude questionnaire reliability test

Reliability Statistics	
Cronbach's Alpha	N of Items
0.610	17

A non-test instrument, namely a scientific attitude questionnaire, was also prepared to find out the scientific attitude of students before and after being treated using product. The empirical test of the scientific attitude questionnaire obtained a reliability of 0.610 which was interpreted with high reliability. The results of the validity of the scientific attitude questionnaire can be seen in Table 2.

Development stage

The stages that have been compiled and designed in advance are combined into one in the development stage. The development stage is the stage of product assessment by experts to product implementation so that the final product of the enrichment book of chemistry in our body based on augmented reality can be produced. The activities carried out in the development stage are product validation by experts, practicality tests by chemistry teachers, readability tests, limited trials, and field trials. A summary of the validation results by media experts on each aspect of the assessment is presented in Table 3.

Table 3. Validation results by media experts

No.	Aspects	Average score	Maximum score	Percentage of ideality (%)	Category
1	Display	49	50	98.00	Excellent
2	Practicality	15	15	100.00	Excellent
3	Software Engineering	29	30	96.67	Excellent
Average		92.5	95	97.36	Excellent

Table 4. Validation results by materials experts

No.	Aspects	Average Score	Maximum Score	Percentage of Ideality (%)	Category
1	Eligibility	24	25	96.00	Excellent
2	Language	15	15	100.00	Excellent
3	Serving	24.5	25	98.00	Excellent
4	Characteristics of enrichment book of chemistry in our body based on augmented reality	20	20	100.00	Excellent
Average		83	85	97.64	Excellent

Based on the data in Table 3, it can be seen that the product from the three aspects of feasibility assessment by media experts obtained the "Very Good" category with an average value of 97.36% for the overall aspect. A summary of the validation results by material experts on each aspect of the assessment is presented in Table 4. Based on the data in Table 4, it can be seen that the product from the four aspects of feasibility assessment by material experts obtained the "Very Good" category with an average score of 97.64% for the overall aspect.

Disseminate stage

Based on expert validation, practicality tests by chemistry teachers, and readability responses by students, the enrichment book of chemistry in our body based on augmented reality is revised so that it can be used in classroom learning. A wide trial was used to determine the validity of augmented reality-based chemistry enrichment books for students empirically and their effects on chemical literacy and scientific attitudes towards macromolecular materials in particular and chemistry in general.

Expert assessments are carried out by lecturers, media experts, and material experts as validators of product feasibility. The feasibility of products based on media is assessed from the aspect of appearance, practicality, and software engineering. The feasibility of the product based on the material is assessed from the aspects of content feasibility, language aspect,

presentation aspect, and characteristics of augmented reality-based enrichment books. The results of the product feasibility assessment by lecturers, media experts and material experts stated that the enrichment book of chemistry in our body based on augmented reality is suitable for use in field research and is included in the "Very Good" category with an average percentage of ideality of 97.36% for media and 97.64% for material. The practicality test by 3 chemistry teachers was included in the "Very Good" category with an average ideality percentage of 88.62%. The response of the product readability in a limited trial by students showed an average of 81.21% ideality percentage which was included in the "Very Good" category. In the extensive trial, there were 55 students who responded to the product developed. The results of students' responses to the Enrichment Book of Chemistry In Our Body Based on Augmented Reality are presented in Table 5 and Table 6.

Table 5. Results of the response of class XII sicence 1 students to enrichment books based on augmented reality

No.	Aspects	Average Score	Maximum Score	Percentage of Ideality (%)	Category
1	Serving	21.68	25	86.72	Excellent
2	Practicality	12.18	15	81.20	Excellent
3	Software Engineering	25.21	30	84.03	Excellent
Average		59.07	70	84.39	Excellent

Table 6. Results of the response of class XII sicence 2 students to enrichment books based on augmented reality

No.	Aspects	Average Score	Maximum Score	Percentage of Ideality (%)	Category
1	Serving	21.04	25	84.16	Excellent
2	Practicality	12.07	15	80.47	Excellent
3	Software Engineering	24.22	30	80.73	Excellent
Average		57.33	70	81.90	Excellent

Based on Tables 5 and 6, it shows that the average score of students' response to the enrichment book of chemistry in our body based on augmented reality for all aspects in class XII Science 1 is 84.39% and class XII Science 2 is 81.90% so it is included in the "Very Good" category. Based on the results of limited trials and wide trials, it can be concluded that the enrichment book of chemistry in our body Based on Augmented Reality is very good for use in chemistry learning.

Teaching material models added with Augmented Reality (AR) technology have become part of the learning trend in the 21st century. In education, the use of augmented reality technology aims to achieve better learning effects compared to using traditional teaching methods. Creating educational content that uses augmented reality technology can be a challenging task for an educator (Pantelic & Vukovac, 2017). This is in line with research conducted by Pramono & Setiawan (2019) showing that students are happier and more enthusiastic in utilizing augmented reality-based learning media. The results of the Manova Multvariate Tests can be seen in Table 7.

Table 7. Result of multivariate test

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Pillai's Trace	0.243	8.341	2.000	52.000	0.001	0.243
Wilks' Lambda	0.757	8.341	2.000	52.000	0.001	0.243
Hotelling's Trace	0.321	8.341	2.000	52.000	0.001	0.243
Roy's Largest Root	0.321	8.341	2.000	52.000	0.001	0.243

Based on the results of the Multivariate Test table above, a significance value of 0.001 < 0.05 was obtained, that it can be concluded that there is a significant difference in chemical literacy and scientific attitudes between the experimental class that uses enrichment book of chemistry in our body based on augmented reality and the control class that uses teaching materials commonly used by schools. The results of the above two data analysis shows that the chemical literacy and scientific attitudes of students in the experimental and control classes become different after being treated.

In the Manova test wich can be seen in Tabel 7, the results were obtained that there was a significant difference in chemical literacy ability between the experimental and control classes. It can be concluded that there is a significant difference in chemical literacy skills between students who are taught using enrichment book based on augmented reality and teaching materials commonly used in schools. The results of the Test of Between Subject Effect showed a significance value of chemical literacy of 0.001 which was smaller than 0.05.

The enrichment book of chemistry in our body based on augmented reality developed can improve chemical literacy because it has the ability to convey something abstract and difficult to explain if only using 2D or with traditional methods. The enrichment book developed makes the material simpler and easier to convey. This is supported by research conducted by Suryaningsih (2019) that displaying visuals, audio, and video in learning media such as augmented reality-based teaching materials can increase effectiveness in student literacy activities.

In the manova test wich can be seen in Tabel 7, the results were obtained that there was a significant difference in scientific attitudes between students in the experimental class and students in the control class. It can be concluded that there is a significant difference in chemical scientific attitudes between students who are taught using enrichment book based on augmented reality and teaching materials commonly used in schools. The results of the Test of Between Subject Effect showed a significance value of scientific attitude of 0.001 which was smaller than 0.05.

In research conducted by Indriani et al. (2023) it was shown that the manual, a project-based learning model with augmented assistance, was able to improve the science process skills and scientific attitudes of students. This is in line with research conducted by Astuti (2020) that 3D visualization media can effectively improve students' science process skills and

scientific attitudes. In addition, augmented reality technology can also improve students' scientific attitudes (Adebusuyi et al., 2020). This is also strengthened by research conducted by Bakar & Sugiyarto (2019) that the application of learning media can improve students' scientific attitudes. Students in the experimental class experienced a higher increase in scientific attitudes compared to the control class, but most students still experienced an increase in scientific attitudes in the low category.

The research conducted at Angkasa Adisutjipto High School used the 2013 curriculum. The study was conducted on 55 students who were divided into 28 students as an experimental class and 27 students as a control class. The use of enrichment book of chemistry in our body based on augmented reality makes an effective contribution to the learning process. The results of the multivariate test obtained an effective contribution value of 24.3% for enrichment book of chemistry in our body based on augmented reality, which means that enrichment book of chemistry in our body based on augmented reality simultaneously have a positive influence on chemical literacy and scientific attitudes of students who use enrichment book based on augmented reality.

Conclusion

The feasibility of the enrichment book of chemistry in our body based on augmented is included in the "Very Good" category to improve students' chemical literacy skills and scientific attitudes based on assessments by media experts and material experts with an average score of 97.36% for media experts and 97.64% for material experts. The practicality test by chemistry teachers on the product is included in the "Very Good" category to be used in learning with an average score of 88.62% and the readability/response test of students to the product was included in the "Very Good" category to be used in learning with the average score obtained from a limited trial of 81.21% and a wide trial of 83.14%. The enrichment book of chemistry in our body based on augmented is effective in improving students' chemical literacy and scientific attitudes with the multivariate test which obtained a significance value of 0.001 and has an effective contribution of 24.3% to students' chemical literacy and scientific attitudes.

Conflict of Interests

The author declares that there is no conflict of interest in this research and manuscript.

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