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Augmented reality integrated chatbot to improve learning outcomes in secondary school students.

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ABSTRACT

The major challenge in learning science is that it is abstract and complex for some students to understand. For example, elements and compounds cannot be seen directly in very micro-sized objects; therefore, visualizing this concept can be challenging. Another challenge is the limited time for teachers to answer questions, provide explanations, and provide feedback during the learning process. This study aims to develop augmented reality learning tools integrated with large language models in the format of a chatterbot text-to-text that can be utilized on the topic of elements and compounds. The development model that has been implemented is adapted from the Lee and Owen model, which includes need analysis, front-end analysis, design, development, implementation, and assessment. Media and content experts have assessed the technology's suitability for classroom learning for 8th-grade students of Salafiyah Junior High School in Pekalongan. Based on field implementation, this technology obtained a positive perspective and indicated an improvement in learning outcomes on element and compound topics. The integration of AR and ChatBot contributes significantly to the innovative classroom learning process and creates a learning experience that suits the needs of students in this digital era.

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ABSTRAK

Kendala utama dalam pembelajaran IPA yaitu abstrak dan sulit untuk dipahami oleh beberapa siswa. Contohnya konsep mengenai unsur dan senyawa yang tidak bisa dilihat dalam bentuk secara langsung dalam objek yang berukuran sangat kecil, sehingga memvisualisasikan konsep ini bisa menjadi tantangan. Tantangan lain berupa waktu yang terbatas untuk guru dalam siswa dalam menjawab pertanyaan, memberikan penjelasan, dan memberikan umpan balik selama proses pembelajaran. Studi ini bertujuan untuk mengembangkan media pembelajaran berupa augmented reality terintegrasi large language models dalam bentuk chatterbot teks ke teks sehingga dapat digunakan pada topik tentang unsur dan senyawa. Model pengembangan yang telah dilakukan diadaptasi model Lee dan Owen, yang meliputi analisis kebutuhan, analisis awal akhir, desain, pengembangan, implementasi, dan penilaian. Ahli media dan ahli materi telah menyatakan kelayakan untuk digunakan dalam pembelajaran kelas pada siswa kelas 8 SMP Salafiyah Pekalongan. Berdasarkan implementasi lapangan, teknologi ini memperoleh perspektif yang positif dan menunjukkan adanya peningkatan hasil belajar pada materi unsur dan senyawa. Integrasi dari AR dan Chatbot memberikan kontribusi signifikan bagi sebagai media pembelajaran dalam proses pembelajaran kelas yang inovatif dan menciptakan pengalaman pembelajaran yang sesuai dengan kebutuhan siswa di era digital saat ini.

Kata Kunci: *artificial intelligence; large language models; pembelajaran IPA; realitas berimbuh*

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INTRODUCTION

In this digital era, the use of technologies in learning has become the main focus of improving the quality and effectiveness of the learning process. One of them is the learning media of science that uses Augmented reality, which has developed in the last five years, for the concept of sound (Cai et al., 2022), improve creativity (Wu & Wu, 2020), teaching geometry (Ibili et al., 2020), exploration science (Lah et al., 2024), and tracking complex concepts in science (Yang & Wang, 2023). Another technology that has become a hot topic in the education process is Artificial Intelligence (AI). AI in education can be used as a learning aid and has become a trend in recent years, such as assessment (Chen et al., 2023), simulation (Scherr et al., 2023), and practice learning (Eager et al., 2023). This is achieved through the learning process at the junior high school level, which requires innovative and relevant approaches to adapt to the needs of Generation Z students who have grown up in the digital era. One of the emerging promising technologies to be applied in the context of learning is Augmented Reality (AR) and artificial intelligence language models such as ChatGPT.

On the other hand, observing learning challenges at SMP Salafiyah Pekalongan in Pekalongan City has found obstacles in increasing students' interest and understanding of science learning. One reason is that students struggle to understand abstract scientific concepts due to the lack of interactive and practical learning opportunities (Thaariq et al., 2023). Many scientific subjects, such as quantum physics, molecular biology, and chemical reactions, include objects that cannot be physically touched or looked at directly. This often makes it tricky to understand the lack of specific illustrations or examples. In addition, although science is a subject that involves procedures, particularly in terms of conducting scientific practicum, there are still no adequate laboratory facilities available. This is due to the low ratio of laboratory equipment to students and reduced learning opportunities through practical experiments due to outdated and insufficient equipment. However, understanding ideas and theories that overemphasize memorizing rather than experiential learning creates barriers to successful teaching and learning, which decreases students' motivation to learn (Chaturvedi et al., 2023).

The constraints of teaching natural science lessons are experienced on elements and compounds. Chemical concepts such as atoms, molecules, and chemical bonds can be abstract for some students if only displayed in a picture. In addition, to demonstrate chemical concepts directly, teachers need access to appropriate tools and materials. However, limited facilities and school budgets can hinder providing the necessary tools and materials. On the other hand, adequate assignments to measure students' understanding can be challenging for teachers when the time available in the curriculum is limited (Thaariq, Yulianto, et al., 2023). Moreover, elements and compounds can be difficult or tedious topics for some students, resulting in a lack of engagement in learning. Teachers must find ways to make the material more interesting and relevant for students (Thaariq, Nurdiyanto, Karima et al., 2023).

To overcome this situation, developing learning tools that integrate AR technology with ChatBot is relevant as a solution to improve learning outcomes in junior high schools (Brown et al., 2021). The AR-based chatbot system significantly influenced the indicators in the ARCS motivation model; therefore, the intention to use this system is expected to result in a marked improvement in student learning outcomes when using the system (Chuang et al., 2023; Alfianti et al., 2023). Integrating AR can create an immersive and fun learning experience for students. ChatGPT, the example of the chatbot, can act as a virtual assistant that assists students in answering questions, providing explanations, and providing feedback during the learning process (Sallam, 2023). This system's development is expected to positively contribute to increasing students' interest, engagement, and understanding of science materials in junior high school. Instead of considering the dangers of ChatGPT, it is preferable to focus on how the technology can improve

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student learning outcomes. Mobile learning technology for features like Augmented reality and large language models can be developed using Unity software (Tlili et al., 2023).

In the classroom, the teacher presents the lesson in a conventional method by showing pictures of molecules and direct learning by the teacher. The teacher only visualizes the content by illustrating pictures in the book or drawing on the blackboard. This kind of classroom learning still does not involve students in running interactive learning. Augmented reality can visualize concepts and theories on elements and compounds (Ardyansyah & Rahayu, 2023). However, this research has not examined the problems at the junior high school level. In addition, the teacher has not been able to answer all questions in detail from active students during learning and only chooses a few people. This is due to the teacher's lack of time to answer many questions. There is a lack of time to create personalized learning by approaching students with their questions about the theories and concepts they face in learning. To overcome this problem, research has been conducted by Cuang, which shows AR can be integrated with Chatbot as an online teaching method that helps teachers improve learning outcomes by answering questions from students via Facebook (Chuang et al., 2023). In Shloul's research, ChatBot such as ChatGPT can play a role in active learning to improve learning performance through personalized feedback, interactive learning, and innovative teaching methods (Al-Shloul et al., 2024). Nevertheless, no existing research focuses on the role of ChatBot in science learning at the junior high school level.

From these two cases, it is necessary to integrate augmented reality with a chatbot that can display concept visualizations of elemental topics and answer inquiry questions from students from elemental exploration results. The purpose of research and development is to develop augmented reality learning media products integrated chatbot according to the needs of grade 8 in SMP Salafiyah Pekalongan students on element, compound, and mixture materials in improving learning outcomes.

LITERATURE REVIEW

Science Learning

The science learning experience emphasizes scientific process activities in learning more. Science learning is a learning process that involves understanding various aspects of the universe and the phenomena that occur in it. In learning Natural Sciences, especially on the topic of Elemental and Molecule Properties for junior high school level, learning content can be divided into four main construct types: facts, concepts, principles, and procedures. Science learning at the junior high school level generally uses an inquiry-based approach that encourages students to engage in exploration, observation, and experimentation actively. According to Krajcik, this approach allows students to build their understanding through hands-on experience (Wörner et al., 2022). The process of understanding natural phenomena can be explored in both real and virtual conditions.

Characteristics of Generation Z Students

Science learning at the junior high school level has been the focus of attention for educators and researchers to improve students' understanding and interest in science materials. Generation Z students, who are digital natives, require a learning approach that suits their characteristics and preferences. Huang et al., in "*Educational Technology: A Primer for the 21st Century" said that Generation* Z students grow up in an era of digital technology, where information accessibility and the use of technology are an essential part of their daily lives. Inquiry-based learning has been recognized as effective in improving junior high school student's understanding and mastery of science concepts. According to Roblyer and Doering in "*Integrating Educational Technology into Teaching"* this approach encourages students to actively engage in learning through experimentation, observation, and data analysis. This approach aligns with the

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characteristics of Generation Z, which prefers interactive and exploratory learning. Gilbert and Justi, in "*Modelling-Based Teaching in Science Education*" said the presence of digital technology is a change in learning interactions from observing natural phenomena packaged as virtual models in science learning in the classroom.

Augmented Reality as a Learning Tool

Augmented reality in science learning is used for abstract materials that are too large or too small to see, too dangerous to observe, too expensive to implement, and complementary to a real object (Alizkan et al., 2021). It takes an object or real-world setting as a foundation and incorporates technology as a target place to add virtual data so that the addition of an object appears. Only by using a mobile phone or laptop can we observe something without doing it directly. Augmented reality can also support active learning scenarios like problem-based or discovery learning (Karakus et al., 2019). This technology can bring real and virtual objects together. It can contribute to students' learning experience with specific learning difficulties, safe environments from time and distance with the simulation of abstract or expensive concepts, and dangerous experiments (Turan & Atila, 2021). Using augmented reality, students can explore virtual objects directly representing scientific concepts in their natural environment (Chang et al., 2020). Students can see, touch, and interact with three-dimensional models of molecules.

Large Language Model in Science Learning

A chatbot or chatterbot is computer programming that simulates human conversation through voice commands (voice to voice), text chat (text to text), or both. ChatBot are currently supported by Large Language Model Database (LLMs), increasing the supporting data. ChatGPT, Google Bard, and Microsoft Copilot are examples of trending LLMs (Kasneci et al., 2023). LLMs will most likely be helpful for educators designing lesson units, syllabi, and quizzes. Educators should critically evaluate and adapt AI-generated learning resources to their teaching context. Research results show that specific and interactive prompts for ChatGPT user conversations have generated responses with more feature components and more accurate and reliable information (Lo, 2023). However, specific prompts require understanding the knowledge domain, and interactive prompts require a deeper understanding of two or more further steps regarding the knowledge or conversation (Liu, 2023). Prompts are essential in guiding AI models like ChatGPT but can be prone to several pitfalls. Key challenges include ambiguity, reinforcement bias, over-customization, lack of context, ethical considerations, unintended side effects, and unrealistic reliance on model limitations (Giray, 2023).

Integration of Augmented Reality with Artificial Intelligence in Science Learning

Integrating augmented reality (AR) with ChatBot merges two different but complementary technologies in a learning context. These two technologies can be integrated into one mobile learning. Augmented reality is a technology that allows users to view and interact with virtual objects displayed on top of the natural world through technological devices such as smartphones or AR glasses. On the other hand, ChatGPT is an artificial intelligence language model that uses natural language processing (NLP) technology to understand and generate text in human language. Students who are confused about a concept can ask ChatGPT questions for additional explanations (Cooper, 2023). ChatGPT will not replace the exploration of natural or laboratory phenomena but will help to provide information immediately based on the personalization of the student. Nevertheless, there is a concern about the ethics of using text-to-text-based LLMs in the process of composing lab reports or scientific writing (Wang, 2023).

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Element and Compound

Maryana et al., in "*Ilmu Pengetahuan alam untuk SMP Kelas VIII*" by Pusat Perbukuan Badan Standar, Kurikulum, dan Asesmen Pendidikan, said the elements and compounds topics at the grade 8 junior high school level in the independent curriculum include basic concepts about elements, compounds, and chemical reactions. Students are expected to understand that elements are pure substances consisting of the same atoms, while compounds are combinations of two or more elements in a fixed ratio (Oktariani et al., 2020). Next, students learn about chemical symbols for elements and how to read them. They recognize common elements and symbols, such as H for hydrogen, O for oxygen, and C for carbon. Wasis and Irianto, in the book "*Ilmu Pengetahuan Alam 2: SMP/MTs Kelas VIII*" by Pusat Perbukuan Departemen Pendidikan Nasional, said the material at the junior high level does not delve in depth; students are introduced to atomic structure, which means that an atom consists of a nucleus made up of protons and neutrons, surrounded by electrons. Furthermore, students learn the basics of chemical reactions, such as forming compounds from elements through chemical reactions. They can obtain examples of formation reactions, such as water formed from hydrogen and oxygen. This content is presented in a context relevant to students' daily lives, such as using compounds in household or industrial products.

METHODS

The research method adopted the structured model adapted from Lee Owen's Multimedia Based Instructional Design. Lee and Owens, in the book "*Multimedia-Based Instructional Design: Computer-Based Training, Web-Based Training, Distance Broadcast Training*" said this model needs analysis, front-end analysis, design, development, implementation, and evaluation. This model presents structured and concrete steps in developing augmented reality multimedia integrated with Chatbot.

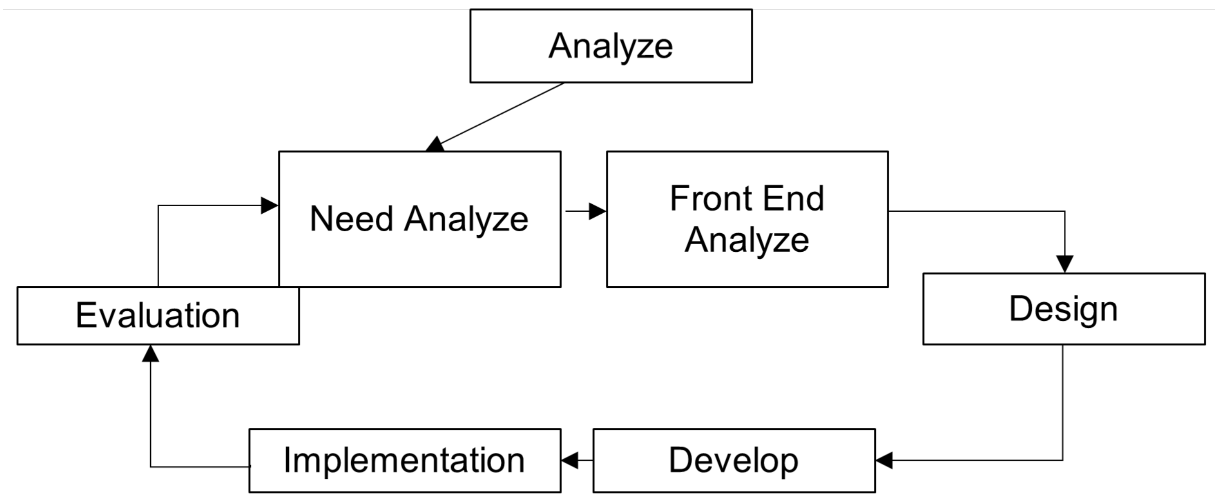

Figure 1. Lee Owen's Model Development of Multimedia Instructional
Source: Lee and Owens in the book "*Multimedia-based Instructional Design: Computer-based Training, Web-based Training, Distance Broadcast Training*"

Figure 1 Indicates that Lee Owen's model provides systematic steps from analysis conditions to evaluation methods to achieve the learning goals of AR Chatbot. By utilizing this model, we can identify and comprehend the process of executing procedures and identify the parts of the multimedia that require improvement or optimization. This assists in enhancing efficiency, reducing errors, and improving the overall performance of the developer team. The sequence of steps of the Lee Owen model on this application that have been implemented are:

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1. Need Assessment

We identified differences in actual conditions and ideal needs so that developers can satisfy these ideal needs. The ideal condition for learning science material is to adjust it to the curriculum that applies at school. In this research, two aspects are evaluated: the need for practicum and the interaction requirements of the learner. SMP Salafiyah only has two lab kits for about 30 students. Therefore, we require more practicum kits and modeling kits to support all students in the class. The abstract subject areas and being prone to misconceptions pose significant challenges for students in understanding complex concepts. A solution is required to overcome the problem of the number of simulation kits available to provide adequate learning experiences to students. In addition, teachers require learning tools that efficiently deliver the topic of elements and compounds in the time available. In addition, a solution is necessary to tackle the teacher's limitations in responding to students' questions and intensively checking students' answers because of time and resource limitations.

2. Front end analysis

Researchers analyzed the difficulties students experience in the science learning process at school. One obstacle is the lack of student attention in learning science, shown by behavior such as sleeping or chatting off-topic during learning. The teaching method still practiced is lecturing while writing material on the blackboard. This method is too theoretical. Without enough practical experiments, science material can feel more complex and less enjoyable for students.

We analyzed the material concepts that are an obstacle in teaching the topic of elements and compounds. One involves concepts that cannot be viewed or directly felt because compounds are very small. This makes the concept difficult to understand without concrete representations or examples. We also analyzed the material's content to be developed in the application.

The student analysis found that most students already have personal or family smartphone access. The use of smartphones is prevalent in students' daily lives, including the school environment. In addition, our observation showed that the environment of SMP Salafiyah Pekalongan is located in the center of Pekalongan City. Hence, it has proper internet access and many facilities that can be leveraged. From the point of view of technological conditions, the development of digital learning media is more efficient and inexpensive compared to the production of real laboratory kits based on student ratios. In terms of time advantage, the additional learning time in the classroom on the topic of elements and compounds will disrupt the semester plan regulated in the curriculum in effect at the school.

3. Design

We design schemes and plan strategies to produce products that meet the needs and analyze problems. Researchers compiled a work plan according to the target discussed with related parties in designing the desired application specifications and created an application flowchart to overcome science learning obstacles. Lastly, researchers compiled assessment instruments based on predetermined indicators.

This application's user interface is designed to facilitate the acceptance of material per the instructions for delivering concepts. The application has been numbered according to the content delivery stages, which junior high school students easily understand. The flowchart of the application can be viewed in Figure 2.

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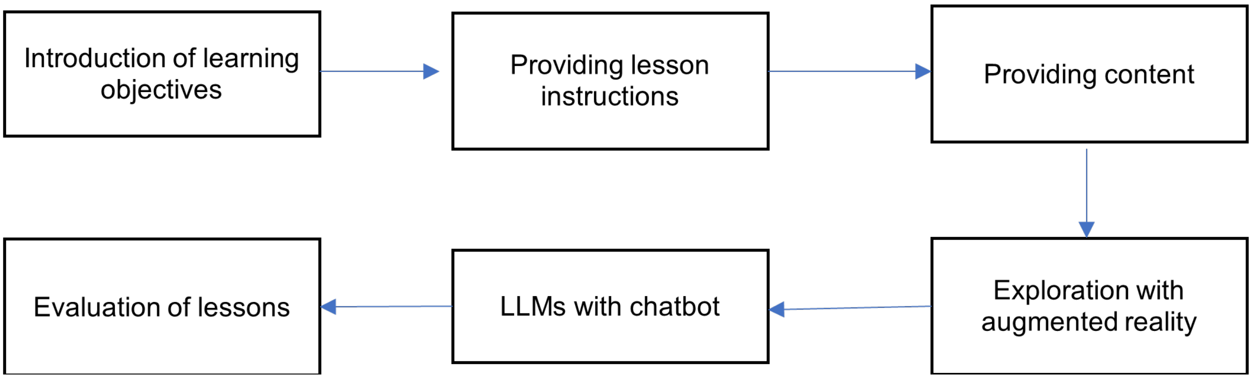

Figure 2. Flowchart of AR-Chatbot
Source: Author's Documentation 2024

4. Develop

We developed the AR-integrated chatbot according to the design that we discussed together. Firstly, we prepare the material from semi-electronic books published by the Ministry of Education and Culture of the Republic of Indonesia. The content includes compound concept, molecule concept, and mixture concept. Furthermore, using 3D blender software, we developed 3D modeling of the primary group elements and the compounds formed from the constituent elements. Next, the user interface was designed using Canva using the available assets. The interface is adapted to the principles of multimedia according to the needs and characters of junior high school students. Furthermore, we utilized Unity 3D software as the primary tool in developing this augmented reality-integrated chatbot application. In modeling the changes in the fusion and diffusion of elements, we used the C# programming language adjusted to the compound's chemical formula. We used the Vuforia Augmented Reality database to show the augmented reality by uploading the marker and copying the Vuforia key code. Meanwhile, we used the unity asset package ChatGPT to Unity, which will be embedded in the created application. We implemented OpenAI's APIKey and embedded a prompt to improve the chatbot's performance. Finally, we iteratively reviewed and built the app for maximum usability by students using smartphones. Students download the application at (https://s.id/ARUnsurSenyawa).

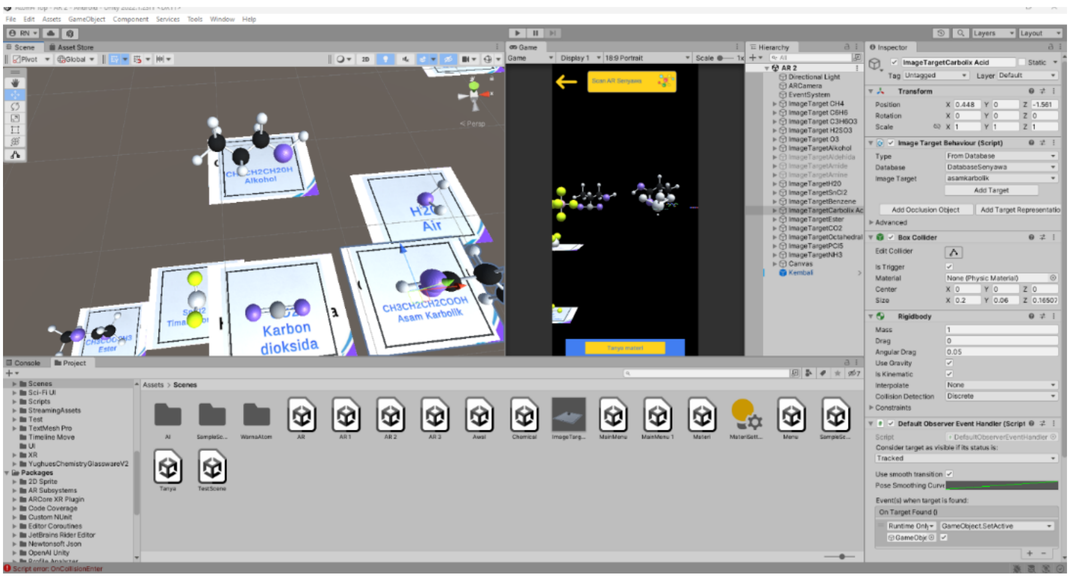

Figure 3. Design Process in Unity
Source: Author's Documentation 2024

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Researchers developed an instrument for language content, media, and design validation as input before implementation. After the product was realized, validation was conducted to test the feasibility of science learning media in junior high school class VIII. This product was validated by experts and examined on the target subjects.

5. Implementation

This stage is the application of Augmented reality media integrated with ChatBoot on the subject as a treatment in the learning process. Implementation was conducted on students at SMP Pekalongan Salafiyah. Phase 1 was carried out with a one-to-one evaluation involving 1 to 6 people to gain feedback in the form of user experience from SMP Salafiyah Pekalongan. Then, a small group evaluation was conducted to find out how much influence there was after using the application in one class at SMP Salafiyah Pekalongan, grade 8. Finally, the field test, which conducted experiments by contrasting conventional learning with the application, was conducted in three classes with around 30 students at Junior High School.

6. Evaluation

Evaluation is done formatively to determine the product's worthiness, and summative evaluation compares learning outcomes using the application with conventional. Formative evaluation is conducted after suggestions and comments from content experts and media experts obtained from the validation questionnaire. A summative evaluation reviews students' learning outcomes and compares them to learning objectives. Evaluation data collection is conducted through tests on students' understanding of science material and questionnaires of students' perspectives on the application. The evaluation results review the lack of a learning system and media and make improvements and adjustments to increase effectiveness.

The study subjects were grade 8 students of SMP Salafiyah Pekalongan. The sample was selected by sampling the population in one class. The learning process was conducted for 10 lesson hours or 400 minutes, divided into six sessions over two weeks.

This research uses a questionnaire with a scale of 1 to 4 to facilitate the data analysis. Media and material experts calculate the average value and analyze the results of the validation process. The pre-test and post-test designs in the development class are used to determine how much improvement is obtained after learning to use chatbot-integrated augmented reality media. Researchers also reviewed students' perspectives on the application by giving questionnaires on aspects such as behavioral intention, perceived ease of use, perceived credibility, attitude, and perceived usefulness.

RESULTS AND DISCUSSION

Product Development Results Augmented reality (AR) media applications in the context of learning chemistry for grade 8 junior high school students in learning element and compound materials. This final product is a mobile learning application with augmented reality and an openAI-based chatbot that can be accessed using a smartphone. This application allows students to visualize elements, compounds, and mixtures in three dimensions by scanning the available markers, which helps better understanding than only through images or text. Abstract concepts in this material, such as atomic structure, chemical bonding, and chemical reactions, can be presented more concretely. Students can see and manipulate molecular models directly by bringing specific element markers closer to others. In addition, there is a Chatbot on each augmented reality menu when 3D objects appear to ask more in-depth questions related to the

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material. As a mobile application, the ability to access learning materials anytime and anywhere can improve the affordability of education. Students can learn independently at home or outside the classroom, and teachers can utilize it as an additional tool in classroom learning.

Figure4. Display of Application
Source: Author's Documentation 2024

In this application, students can observe the structure of atoms by scanning the available markers. When two elements are brought closer together, a reaction will occur that produces a new molecule, such as when the Cl (Chlorine) element marker is brought closer to Na (Sodium).

Figure 5. Augmented Reality in Elements and Compounds Material
Source: Author's Documentation 2024

From Figure 5, students can learn about the 3D modeling of several molecules, such as lactate acid, alcohol, dioxide, etc. The markers are customized with image coding on each marker to distinguish between element markers, compound markers, and mixture markers. Students also learn about fusion and diffusion using several interactions of elements, such as NaCl, H_2O, and FeCl.

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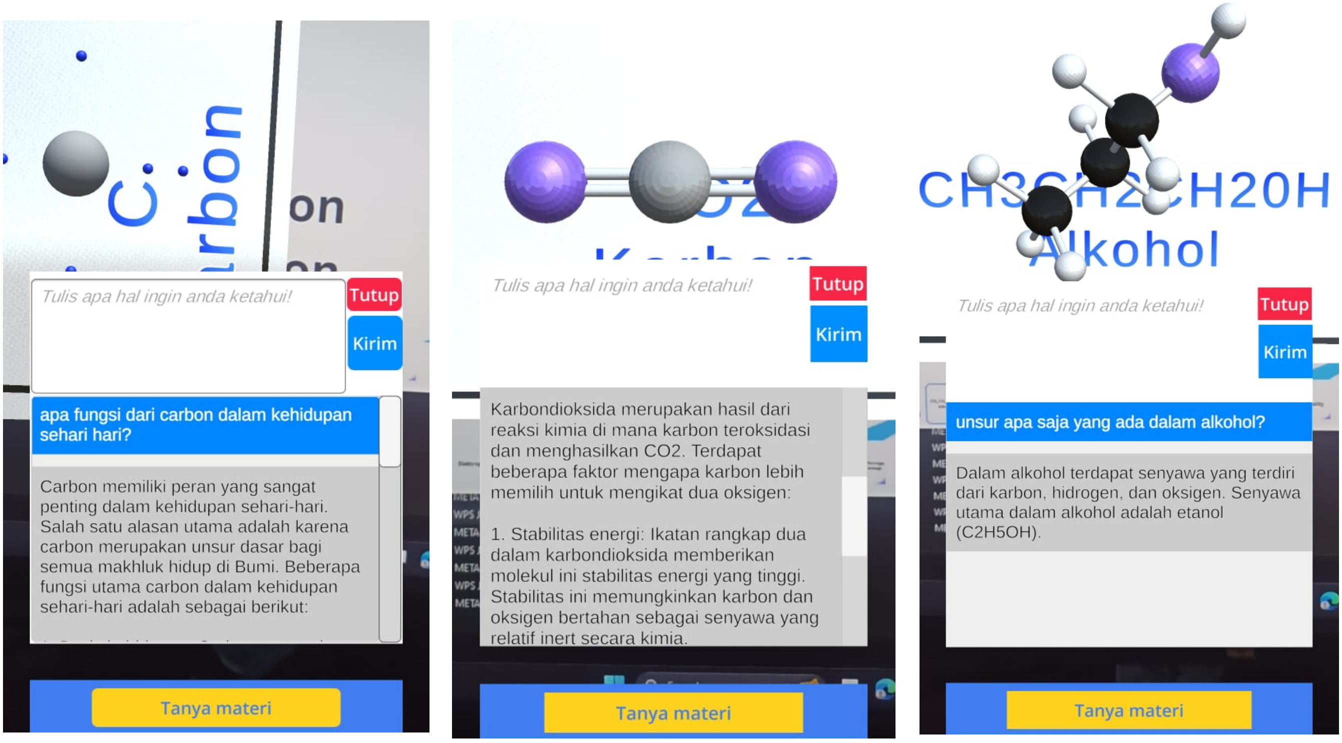

Figure 6. ChatBot as Learning Tools
Source: Author's Documentation 2024

From Figure 6, students ask several questions and gain feedback automatically. Students can ask questions using a proper prompt according to their intent. Improvements in prompts support learners in producing good answers according to the concept and planned learning objectives.

Validation of Application

The first validation stage was conducted with two expert validators to test the feasibility of the content developed following the learning objectives. Content validators are SMP Salafiyah teachers who have taught the tested class and will teach using this media. Aspects and results of validation are shown in the following **Table 1**.

Table 1. Result of Validation form Subject expert

No	Aspect	V1	V2	Category
1	Learning Suitability	3.8	3.6	Worth
2	Function	3.8	3	Worth
3	Appropriate Content	3.3	3	Worth
4	Easy to Understand	3.4	3.4	Worth

Source: Research 2024

The expert examined the application and gave scores, including aspects such as learning suitability, the function of AR-Chatbot, appropriate content about the element, and ease of understanding the concept of the element. Table 1 shows that the validation of the chatbot-integrated AR application is feasible to use to explain concepts and theories on elemental, compound, and mixed materials. The Learning Suitability

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aspect shows that this application is suitable for learning elemental and compound materials. However, there is still little room for improvement in adding material contextuality and assessment features. The application functionality indicates that the application has been able to carry out essential functions following the learning objectives. However, the developer still needs improvements to the visualization and ChatGPT prompts to improve the performance of the available features. Regarding the existence of content, it is appropriate to present it to elementary school students. The presence of the chatbot provides adjustments or additions to the content to suit the needs and better personalize learning. In terms of convenience, junior high school students consider this application relatively easy to understand. However, there are revisions to the visualization of elemental objects, and the number of electrons in each element needs to be adjusted. After that, researchers conducted validation of media experts.

Table 2. Result of Validation from Media Expert

No	Aspect	Score	Category
1	Interface Design	3.8	Worth
2	Attractiveness	3.4	Worth
3	Utilization	3.4	Worth
4	Multimedia principle	3.6	Worth

Source: Research 2024

Table 2 above shows that this media can convey material messages according to student characters and conditions in the classroom. The results show that the display is feasible and appropriate for junior high school students. This indicates that the application's interface and navigation have been designed well enough, but a bit of improvement is required to improve readability and clarity. However, some displays do not follow multimedia principles in providing the order of the application menu.

Result of Field Implementation

First, by using a pre-test, we can measure students' initial understanding before they receive instruction on the material to be learned. Then, a post-test is conducted after the learning period to assess the improvement of students' knowledge after they have received the materials and learning intervention. We analyzed the data by examining the normality and homogeneity of the pre-test and post-test data from 30 grade 8 students. The resulting data shows the prerequisites for conducting the T-test, which are **listed in Table 3** and **Table 4**.

Table 3. Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Pretest-Postest	Statistic	df	Sig.	Statistic	df	Sig.
Learning Outcome	Pretest	.146	30	.103	.938	30	.079
	Posttest	.194	30	.005	.897	30	.007

a. Lilliefors Significance Correction
Source: Research 2024

The analysis of normality testing listed in Table 3 shows a significance of 0.103 and 0.05 in the Kolmogorov-Smirnov test. This indicates that the p-value. Using the common significance level of 0.05, the p-value of 0.103 is greater than the significance level. Therefore, we have enough evidence to accept the null hypothesis, which means that the pretest and posttest learning outcome data are significantly different and normally distributed.

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Table 4. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Learning Outcome	Based on Mean	1.526	1	58	.222
	Based on Median	1.558	1	58	.217
	Based on the Median and with adjusted df	1.558	1	57.750	.217
	Based on trimmed mean	1.491	1	58	.227

Source: Research 2024

Based on the analysis results presented in Table 4, the value of Levene's statistic is 1.526, and the significance value is 0.222. This indicates that there is not enough statistical evidence to reject the null hypothesis that the variances between the data groups are equal. Consequently, the homogeneity of variance test shows that the variances of the pre-test and post-test data groups are not significantly different.

Based on the precondition test results listed in Table 3 and Table 4, namely normality and homogeneity of variance, we can proceed to do paired sample t-tests to compare pre-test and post-test learning outcomes. We measured the correlation between the pretest and posttest results of Salafiyah Junior High School students' learning outcomes. We used SPSS 26 to support testing the differences between the two groups.

Table 5. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pretest & Posttest	30	.367	.046

Source: Research 2024

The results of the data analysis significance worth 0.046 are below 0,05, showing the difference in learning outcomes before and after learning using Augmented reality with a chatbot. This shows that augmented reality with a chatbot developed can improve the learning outcomes of 8th-grade students of SMP Salafiyah, especially on elements and compounds.

Student's Perspective on The Application AR with Chatbot

Table 6. Results of Student Perspective on the Application

No	Aspect	Mean Score
1	Behavioral Intention	3.6
2	Perceived Ease of Use	3.3
3	Perceived Credibility	3.56
4	Attitude Using	3.4
5	Perceived Usefulness	3.66

Source: Research 2024

Table 6. indicates that students have a positive perspective toward the AR application integrated with ChatBot from various aspects. A score of 3.6 in behavioral intention suggests that students have a high intention to use the AR application with ChatBot in the learning process. They tend to desire to use technology in learning activities strongly. Then, a score of 3.88 indicates that students find the app easy to use. They feel comfortable and confident in using the features of the AR and ChatBot apps, making it easier for them to explore the learning content. Meanwhile, from a perceived credibility perspective,

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students have a mean score of 3,56. This indicates that students perceive the app to be highly credible. They believe that the information provided by the AR app and ChatBot is reliable and relevant in chemistry learning. Then, a 3.4 out of 4 indicates that students have a positive attitude towards using the AR app with ChatBot. They perceive that the technology can help improve their learning experience and welcome its use in the learning process. Lastly, students find the AR app with ChatBot beneficial in science learning. They gain additional value from using the technology to understand chemistry concepts and improve their learning outcomes.

Discussion

Augmented reality learning tools integrated with ChatBot for 8th-grade junior high school science students have been developed for elements and compounds. Devices such as smartphones are chosen to access educational media for several reasons, including device penetration, the number of smartphones, and accessibility. The AR technology used to develop this learning resource is marker-based AR technology, which views virtual objects in the form of a molecule 3D model. This application must have a marker image object scanned by a smartphone camera. SMP Salafiyah students are digital natives familiar with the mobile phone environment. The following research reveals the application of seamless mobile learning for students to be capable of learning virtually and physically in mastering the concept of mobile phones (Hamid et al., 2019).

Integrating augmented reality with ChatBot brings great potential to improving learning outcomes at the junior high school level by creating a more interactive, engaging, and personalized learning experience. The combination of the immersive visual experience of AR with the natural language communication capabilities of ChatBot opens the door for more effective and efficient learning. The structured application makes students' self-efficacy emerge with clear instructions to learn independently (Lambe et al., 2023). In addition, it engages students when they are learning (Subiyantoro et al., 2024).

Students showed actively engaged behavior when using this mobile application. They have utilized the interactive features provided by the AR application to determine the learning objectives, understand the instructions for using the application, explore chemical structures in groups, and ask questions through the chatbot. Students use AR technology to analyze the chemical concepts taught following the learning objectives by invoking the available markers. They can test molecular models in a virtual environment, manipulate elements to form compounds and observe the results of chemical interactions directly through AR. It can create an enjoyable learning process in the classroom, and this environment can increase learning motivation and engagement (Ramansyah et al., 2023). Student collaboration and communication use the application to support students' cognitive improvement (Hidayati et al., 2020). They explored with AR and discussed modeling a phenomenon that appeared virtually. Furthermore, students use Chatbot to ask questions about the concepts they encounter while using AR. They can ask questions about the structure, properties, or reactivity of elements and compounds and use the Chatbot response as reference material or add enrichment content. In addition, communication and collaboration within the classroom environment enhance the understanding of students' thinking by discussing with each other and the chatbot (Zubaidah et al., 2020).

Based on the data from the field trial results, there is an increase in learning outcomes in element and compound material. Providing augmented reality about the shape of components, compound structures, and mixture structures provides concrete visualization to students (Ardyansyah & Rahayu, 2023). Combining two elements into a molecule gives students an understanding of the concept. This aligns with the interactivity built into molecular modeling (Rodriguez et al., 2022). This application allows teachers to reduce the time and cost of accessing content inside and outside the classroom. Augmented Reality (AR) enriches the learning experience by adding digital elements into the physical environment. Ubiquitous

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Learning refers to learning that can happen anywhere and anytime, not limited to traditional classrooms (Suartama et al., 2020). This learning environment supports understanding self-concept during learning with AR technology and pedagogical consultants packaged as an online learning application (Bringula et al., 2021).

The implementation of ChatBot also assists teachers in the efficiency of learning time. Typically, when students want to ask questions, teachers only choose a few students to give feedback due to limited time. A chatbot in this application makes learning time more efficient and personalizes learning for each student (Eysenbach, 2023). This chatbot has used the databases of openAI's APIKey, which has become the best-selling LLM (Rudolph et al., 2023). The chatbot allows for the personalization of learning according to student's needs. When the teacher conveys material with a level of complexity through AR, students can ask the chatbot anything according to their curiosity (Chamorro-Atalaya et al., 2023). This can save the teacher time when providing material to students with various questions. This chatbot has increased students' curiosity about elements and molecules. ChatBot can be invaluable in implementing blended learning, thus providing a more personalized and interactive learning experience for students. It supports combining online and offline learning elements in a traditional classroom setting (Suartama et al., 2019). This behavior is in line with the benefits of AI.

In the implementation, Teachers can employ the chatbot feature to monitor student progress and provide real-time feedback. In digital learning, teachers must actively adapt to emerging technologies (Krismanto et al., 2022). This allows teachers to support student learning proactively. Teachers can use AR technology and ChatBot to encourage student collaboration and discussion. They can design activities that enable students to work together to build molecular models or investigate the properties of compounds together. ChatBot can also be used to share ideas, exchange information, and deepen understanding through discussions (Sulistiani et al., 2023).

Nevertheless, students still misuse the chatbot to find answers to the practice questions given by the teacher. This aligns with research that reveals the adverse effects of using ChatBot (Piccolo et al., 2023). AR can still provide misconceptions to students, especially in concept enrichment. This is because this media specializes in the objectives and conditions of grade 8 junior high school learning. In addition, there are still errors in answers resulting from students' writing prompts that do not follow the provisions. Students still use non-formal questions rather than questions according to language rules. Providing instructions in writing chatbot prompts is essential to generate the expected information (Korzynski et al., 2023).

The research that has been conducted is limited to the effect of the long-term use of these technologies on student learning outcomes in junior high school. Longitudinal studies can help in understanding the impact of this technology on the development of science literacy or critical thinking skills on the phenomenon of elements and compounds. Further comparative research is required to compare the effectiveness of using AR technology integrated with Chatbot with conventional learning methods in junior high school. This can give more precise insights into each learning approach's advantages and disadvantages.

CONCLUSION

Interactive media in an augmented reality integrated chatbot was successfully developed to facilitate learning of science compound material at the junior high school level. This development has gone through validation and revision from content and media experts to make it feasible to use in the learning process. The responses obtained in the trial followed the learning objectives based on the existing conditions in the classroom environment. The results show that integrating AR and ChatGPT can increase students' interest in science learning and improve concept understanding and overall learning outcomes. Students showed

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higher levels of engagement and felt more motivated to learn when using this system. Improved learning outcomes support this compared to prior knowledge. We suggest research to develop similar features to discover other impacts of using this application, such as self-efficacy, student engagement, self-regulation learning, or other issues. Furthermore, other researchers can conduct experimental research between AR technology integrated with Chatbot and other learning media, such as conventional or different technologies. In addition, this media can be developed with innovations of the best learning methods to build a more effective learning experience according to the subject and learning conditions.

AUTHOR'S NOTE

The authors state that there is no conflict of interest related to the publication of this article and confirm that the data and contents of the article are free from plagiarism.

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