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DESIGNING INTERACTIVE LEARNING APPLICATION USING MARKERLESS AUGMENTED REALITY ON CHEMICAL BONDS MATERIAL

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Abstrak: Era revolusi industri 4.0 telah banyak mengubah dan mempengaruhi berbagai aspek dikehidupan kita, termasuk dibidang pendidikan. Salah satu teknologi yang memiliki dampak terbesar saat ini adalah smartphone. Smartphone dapat digunakan sebagai media pembelajaran dalam bentuk aplikasi pembelajaran yang membantu peserta didik memperjelas konsep, menimbulkan semangat belajar, dan akan memberikan pengalaman baru serta menarik. Penelitian ini dilakukan dengan tujuan merancang aplikasi pembelajaran interaktif terintegrasi *Markerless Augmented Reality* pada materi ikatan kimia. Ikatan kimia merupakan salah satu materi kimia yang konsepnya bersifat abstrak sehingga sulit untuk dipahami peserta didik. Penelitian ini merupakan *penelitian Educational Design Resesarch* menggunakan model pengembangan Plomp. Berdasarkan penelitian awal dan tahap prototipe, diperoleh hasil bahwasanya perancangan aplikasi pembelajaran ini telah berhasil berjalan sesuai dengan rancangan melalui *Self-Evaluation* dan menghasilkan prototipe II. Sehingga, media pembelajaran dalam bentuk aplikasi pembelajaran ini diharapkan dapat mendukung kegiatan pembelajaran di sekolah.

Kata-kata kunci: Aplikasi Pembelajaran, *Augmented Reality*, Ikatan Kimia

DESIGNING INTERACTIVE LEARNING APPLICATION USING MARKERLESS AUGMENTED REALITY ON CHEMICAL BONDS MATERIAL

Abstract: The era of industrial revolution 4.0 has changed and affected our lives, including in education. One of the technologies that had a significant impact was the smartphone. Smartphones can be a learning media that helps students clarify concepts, create enthusiasm for learning, and provide new and interesting experiences. This research aims to design a learning application integrated with marker-less augmented reality for chemical bond materials. Chemical bonds are one of the abstract concepts in chemistry, making it challenging for students to understand. This study follows an educational design research approach using the Plomp development model. Based on preliminary research and prototype stages, the design of this learning application has successfully run well according to the plan through self-evaluation and has produced prototype II. Therefore, it is hoped that this learning media, in the form of an application, will support learning activities in schools.

Keywords: *Learning Application, Augmented Reality, Chemical Bonds*

INTRODUCTION

The era of industrial revolution 4.0 has changed human life a lot because most of life today uses technology, information, and communication (Rochmadi et al., 2023). The industrial revolution 4.0 has had an impact on human civilization with fundamental changes in several fields, including education (Dito & Pujiastuti, 2021). The evolution of technology, including smartphones, over the last two decades has had a significant impact on the educational sphere. Current students

(Generation Z) have had access to the internet, computers, smartphones, and/or tablet-like devices from an early age. Therefore, the continuous adaptation and application of new technologies in the learning process, especially those involving students, can be important to stimulate this new generation of students (Plunkett, 2019).

Interactive learning media has experienced a lot of development nowadays, one of which is learning media that is integrated with augmented reality. Augmented reality integrated learning media is a learning media that can be a solution and challenge for learning that requires visual media. Augmented reality is a technology that is developing rapidly in the 4.0 era, where this technology can present objects as if they were real in front of us just by using a smartphone (Rochmadi et al., 2023).

Augmented reality (AR) is a smartphone technology that can be used to experience the visualization of three-dimensional objects with integrated information (Rostianingsih et al., 2019). Therefore, the visualization offered by augmented reality can contribute to a better perception of three-dimensional objects (Dauitbayeva et al., 2021). Augmented reality is divided into two types, namely marker-based augmented reality, which requires a target image to be displayed by the camera, and marker-less augmented reality, which does not require a target image by only using smartphones in the form of an application to be displayed by the camera, so that three object surface detection dimensions can be done more easily (Pooja et al., 2020). Augmented reality that does not require special markers is usually called marker-less augmented reality. Marker-less Augmented Reality uses Augmented Reality without tracking or tracking without special markers (Midak et al., 2022).

Augmented reality is a technology that has the potential to provide a more interactive learning experience. Apart from that, students consider the use of augmented reality as a useful tool to help them in the learning process (Turkan et al., 2017). Augmented reality is a learning medium that is efficient in its use, has an attractive appearance, is able to help students' understanding, and is able to increase students' interest in learning (Bau et al., 2022). The use of augmented reality in the learning process is more fun, interesting, and actively involves students, so it can help students see, do, and learn existing concepts independently (Sarkar et al., 2020). The simultaneous use of the lap book with augmented reality is concluded to be an interesting medium that makes the teacher's work easier, visualizes theories with better quality, increases the level of perception (understanding) of students, and increases the learning outcomes of students where the achievement of these learning outcomes increases. up to 84.61% (Midak et al., 2022).

Based on the opportunities provided by augmented reality technology, research has not been carried out regarding the development of a complete marker-less augmented reality integrated learning application on chemical bonding material. The equipment in question is a learning application that has been developed containing teaching material that helps students understand concepts, the use of marker-less augmented reality, and a quiz that can help students in the learning process. Therefore, this research aims to design a learning application that can display 3D objects in one application without additional paper as a marker and is complete in terms of content

RESEARCH METHODOLOGY

The type of development research carried out is educational design research. Educational Design Research is a structured analysis that requires planning and, afterward, evaluating the educational activities that have been carried out. It is aimed at finding solutions to complex problems in educational practices. There are three stages or phases in this development model, namely (1) the initial investigation stage

(preliminary research), (2) the development or prototyping phase (development or prototyping phase), and (3) the assessment phase (Plomp, 2013).

Preliminary research aims to find out and define requirements for developing a product. This research is limited to self-evaluation activities to produce an application prototype that functions well according to design. Making a prototype is the design stage to realize the product intervention being developed. This research was conducted SMA N 7 Padang, SMA N 10 Padang, and SMA Pembangunan Laboratorium UNP.

Need and Context Analysis

The needs analysis and context analysis carried out at the relevant schools regarding chemical bonding material aim to determine the conditions and needs required by teachers and students. At this stage, questionnaires and interviews were distributed to three teachers, and also questionnaires were distributed to students at SMA N 10 Padang, SMA N 7 Padang, and SMA Pembangunan UNP.

At this initial investigation stage, analysis was carried out using triangulation techniques. Triangulation is the process of combining information from multiple sources to obtain the "correct" or at least more accurate value (Boslaugh & Watters, 2008).

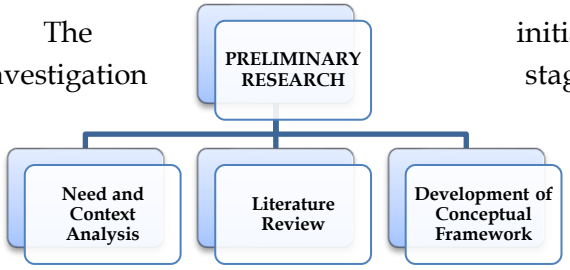
Literature Review

Activities related to methods of collecting library information, reading and taking notes, and managing research materials are called literature studies (Zed, 2008). At this stage of the literature study (literature review), various relevant sources are collected, whether they are books, articles, journals, or other theses related to the research to be carried out.

Development of Conceptual Framework

The conceptual framework begins with determining objectives, which then become the basis for designing, and then identifying facts, needs, and also problems of the phenomena obtained both need & context analysis and literature review.

The initial investigation stage



(preliminary research) was concluded as follows.

Picture 1. Preliminary Research Stage

Initial Plan

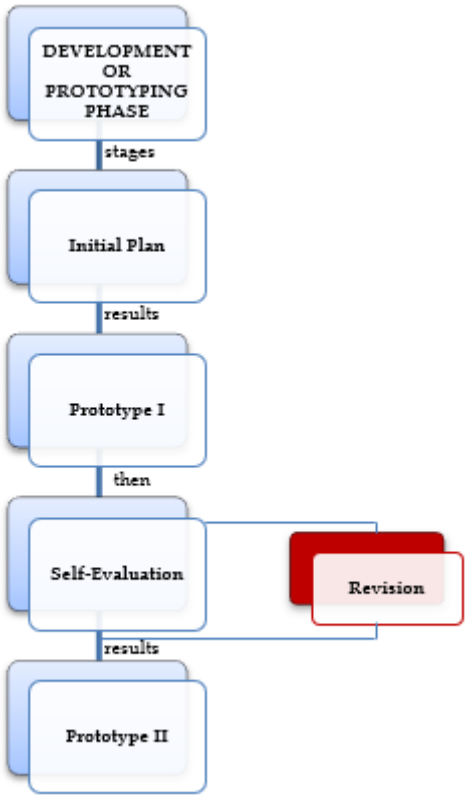
Based on the investigation stage (preliminary research), the application design is an integrated marker-less augmented reality application where several pieces of software are also used. The software used includes Unity 3D, Canva, Visual Studio, Chem Draw and Chem3D, Blender, and Easy AR.

After the initial plan was done, prototype I was formed.

Self-Evaluation

From the designs that have been made previously, prototype I is formed. Then, self-evaluation is carried out. This self-evaluation is carried out after realizing the plans that have been made previously. The method used in this self-evaluation is a check-list method to see the completeness of the prototype I that has been created.

After the self-evaluation was revised, prototype II was formed. During the development or prototyping phase, the prototypes that have been formed are developed, evaluated, and revised, thus carrying out this phase repeatedly. The development or prototyping phase (development or prototyping phase) was concluded as follows.



Picture 2. Prototyping Stage

RESULTS AND DISCUSSION

By using the Plomp development model, this research aims to obtain results that the design of this learning application has succeeded in running according to design so that prototype II is produced.

Need and Context Analysis

The needs analysis and context analysis were carried out at SMA N 10 Padang, SMA N 7 Padang, and SMA Pembangunan UNP by distributing questionnaires to both teachers and students. For teachers, there are also interviews using triangulation techniques.

This chemical bonding material is very important because it is a basic material that can help students understand other chemical concepts because it provides a basic explanation of the process by which a reaction occurs. Chemical bonding material includes two dimensions of knowledge, namely factual knowledge and conceptual knowledge.

Based on initial research conducted by distributing questionnaires to students at SMA N 10 Padang, SMA N 7 Padang, and SMA Pembangunan UNP, data showed that 73.68% of students had difficulty understanding several concepts, and even 19.3% of students had difficulty understanding all concepts. The high level of difficulty students has in studying chemical bonds is reinforced by the fact that 46.81% of students consider the abstract concept of chemical bonding material to be difficult to understand. Even though the media provided by teachers is in the form of text, visuals, and audio, it turns out that students still find abstract concepts in chemical bonding material difficult to understand.

The research results prove that chemical bonding material is difficult for students to understand. The highest percentage of students' difficulties in understanding the concept of chemical bonds is in the sub-concept of covalent bonds, at 58.7% (Kristiana et al., 2020). The percentage of students' difficulty in understanding chemical bonds is also found in the Lewis structure sub-concept, namely 44.1% (Haris & Al Idrus, 2011).

After completing the questionnaire by both teachers and students, the form of media used by teachers is still traditional because they still rely on printed books, student worksheets (LKPD), and also PowerPoint (PPT). This media does not really help explain the abstract concept of chemical bonding material, which requires visualization of three-dimensional objects. This is in accordance with the results of distributing questionnaires to students. 49.12% of students admitted that the media used was still lacking in displaying three-dimensional shapes, only displaying two-dimensional shapes. Thus, some concepts are difficult to present to students in

real life. In fact, nowadays there are many other forms of media based on technology that will really help students understand concepts that require visualization in three dimensions, for example, this integrated marker-less augmented reality technology.

Apart from that, regarding the media used, the results from distributing the questionnaire showed that 26.32% of students still felt that the material presented was not clear. This is because the depiction of existing concepts with the learning media provided is still inaccurate and unclear. This happens because in the chemical bond material, which has an abstract concept, the media used only contains long explanations in the form of text, so students are not interested in reading and understanding the material.

In fact, teachers at these three high schools also admit that the use of media is still simple, so it still doesn't attract the attention of students and still doesn't provide new, enjoyable experiences for them. Media that does not provide new experiences, is less interesting, and is less enjoyable turns out to have an impact on students' activeness in the teaching and learning process.

Apart from that, based on the results of distributing questionnaires and interviews with teachers, the results showed that all teachers from three schools said that less than 75% achieved the minimum score when carrying out the daily tests.

Apart from that, the use of learning media outside of school is still not carried out by all students. Media should be able to be reused as a means of independent learning to help students recall previously learned concepts or to strengthen concepts. This can be seen from the results of distributing questionnaires to students: 54.39% of students do not reuse media outside of school. In fact, many of the media used during the learning process, such as Power Point (PPT) and Student Worksheets (LKPD), are still only used when studying. In fact, based on the results of the questionnaire distribution, 100% of students have devices, especially smartphones, and they also use them at school, so their use should be optimized in the learning process. All teachers also said that they fully support students using devices to assist in the learning process. However, in fact, the use of devices to help during the learning process has not been optimally used because the media used (such as PPT) is usually distributed after the learning process is complete and is not always given by teachers to students. Thus, the use of media that is used to help during the learning process has not been used optimally, and the use of media outside school hours has not been implemented optimally.

Literature Review

Literature studies refer to activities such as collecting library information, reading and taking notes, and managing research materials. Various relevant sources are collected at this stage of the literature study (literature review), whether they are books, articles, journals, or other theses related to the research to be conducted.

Learning media using augmented reality (AR) can make the learning process more fun and interesting and actively involve students. This is in accordance with research conducted by (Sarkar et al., 2020), which concluded that the use of AR helps students see, do, and learn existing concepts independently so that the learning process can be more fun and interesting and actively involve students.

Apart from that, the use of learning media using augmented reality can also significantly increase their understanding. This is in accordance with research conducted by (Hou & Lin, 2017), which concluded that the use of AR helps students increase their level of involvement and acceptance in learning chemical experiments so that their understanding of chemistry, laboratory safety, and making oxygen experiments increases significantly.

The application of learning media using augmented reality compared to without using augmented reality has an effect on the level of student learning motivation and student activity. This is in accordance with research conducted by (Bau et al., 2022), which concluded that the use of AR motivates students to study chemistry and increases student activity.

Apart from that, the application of learning media using augmented reality also influences student learning outcomes. This is in accordance with research conducted by (Harun et al., 2020), which concluded that the use of AR applications helps improve students' educational achievements in the learning process compared to the use of traditional learning methods.

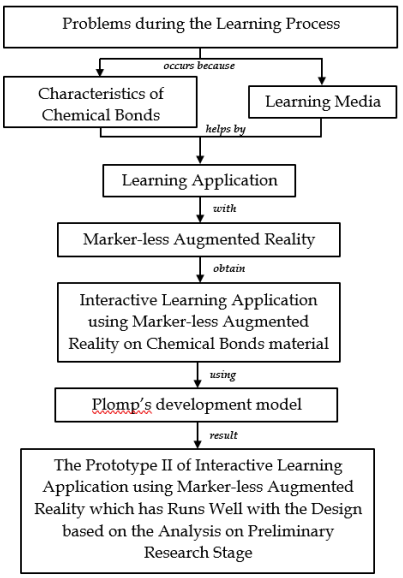
Learning media that use augmented reality can act as an independent learning tool to help students recall previously learned concepts or strengthen concepts outside of school hours. This is in accordance with research conducted by (Zhou et al., 2020), which concluded that the use of AR technology has a positive effect on students' understanding of theoretical subject matter without being limited by time or space, allowing it to be used before class or after school.

Augmented reality mobile-based learning media has the potential to provide an interactive learning experience. This is in accordance with research conducted by (Turkan et al., 2017), which concluded that the use of AR technology is useful in helping students and providing more interactive learning.

Using marker-less, augmented reality-based learning media is easier than using marker-based augmented reality. This is in accordance with research conducted by (Pooja et al., 2020), which concluded that using marker-less augmented reality technology is better because surface detection of three-dimensional objects can be done more easily. Additionally, the use of any digital content such as text, images, and videos can be easily added to this method by importing the required assets in Unity3D without requiring an image target.

Development of Conceptual Framework

The development of the conceptual framework was prepared based on the previous steps, namely need and context analysis and literature review.



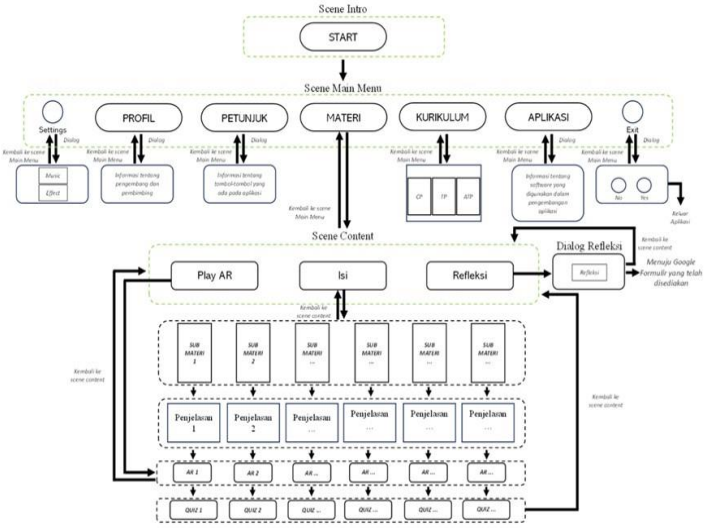
Picture 3. Conceptual Framework

Initial Plan

The application design is an integrated marker-less augmented reality application where several pieces of software are also used. The software used includes Unity 3D, Canva, Visual Studio, Chem Draw and Chem3D, Blender, and Easy AR.

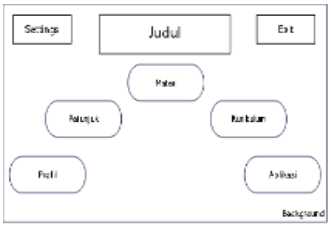
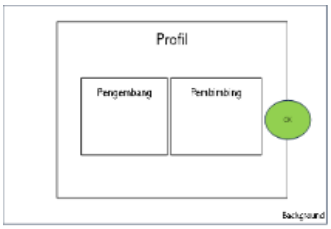
Unity 3D is used as an application creation studio, Canva is used as a graphic design creation studio, Visual Studio is used as a programming language translator, Chem Draw & Chem3D and Blender are used as media to design the required three-dimensional objects, and Easy AR is used as software that creates Augmented Reality (AR) applications that can be used on smartphones. The application design is an integrated marker-less augmented reality application where several pieces of software are also used. The software used includes Unity 3D, Canva, Visual Studio, Chem Draw and Chem3D, Blender, and Easy AR.

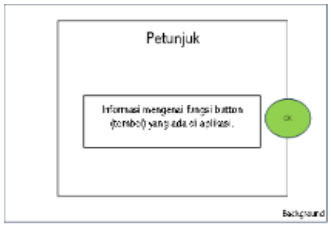
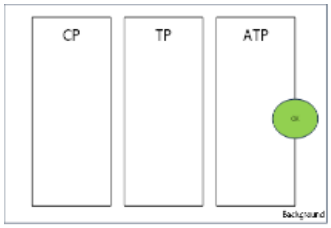
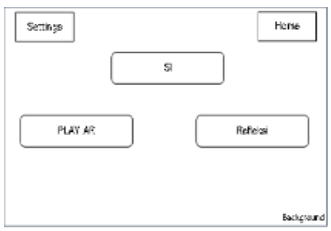
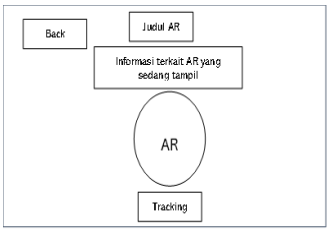
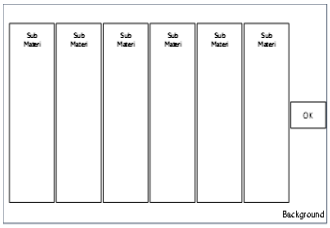
The first step taken in creating an application that integrates marker-less augmented reality is to design and create an application flowchart as follows in Picture 4. After the flowchart is designed, you can then design and create a storyboard for the application as follows in Table 1.

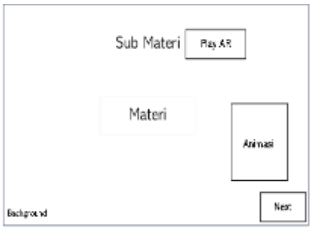
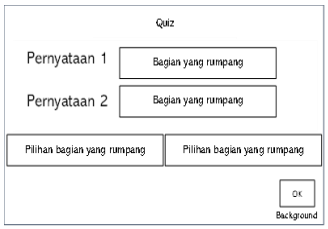
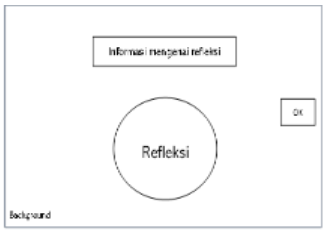


Picture 4. Flowchart

Table 1. Storyboard

Page & Picture	Description
Intro Scene 	**The application begins with an intro display that shows the name and abbreviation of the application. Also, the "START" button will go to the Main Menu.** **The background contains images related to chemistry.**
Main Menu Page 	**The background contains images related to chemistry.** **The main menu contains several buttons that will lead to their respective components, including Settings, Exit, Profile, Instructions, Materials, Curriculum, and Applications.**
Settings 	**A "Settings" pop-up will appear, so users can adjust the music volume and sound effects with the sliding button feature.** **To return to the Main Menu, press the "OK" button.**
Exit 	**A pop-up will appear containing confirmation to exit the application. "Confirm Exit," which contains a "no" button to return to the Main Menu page and a "yes" button to exit the application.**
Profile 	**A "Profile" pop up will appear containing developer and supervisor information.** To return to the Main Menu, press the "OK" button.

Instructions 	**A "Instructions" pop-up will appear, containing information about the functions of the buttons in the application.** To return to the Main Menu, press the "OK" button.
Curriculum 	**A "CP, TP, and ATP" pop-up will appear containing CP, TP, and ATP chemical bond material.** **To return to the Main Menu, press the "OK" button.**
About Applications 	**An "Application" pop-up will appear, containing information on the software used in application development.** **To return to the Main Menu, press the "OK" button.**
Material Page 	**The material contains several buttons, namely the "Settings" button to adjust the music and sound effects and the "Home" button to return to the Main Menu.** **Apart from that, it also contains buttons that will go to their respective components, including Content, Play AR, and Reflection.**
Play AR 	**Play AR displays 3D objects according to the material being taught.** **The "Tracking" button helps users display 3D objects. Users will observe 3D objects that appear in relation to the material via the "Start Tracking" button, and to stop object movement, they can use the "Stop Tracking" button. Apart from that, the object can also be enlarged, reduced, and rotated using two fingers. Meanwhile, to return to the Materials page, press the "Back" button.**
Contents 	**The content has several sub-materials that can be selected by the user.** To return to Material, press the "OK" button.
Sub-material	**The sub-material contains a brief description of the sub-**

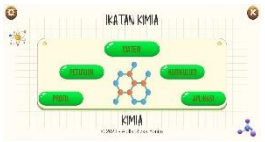
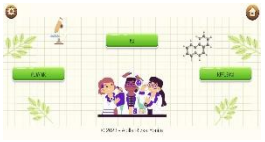
	**material, containing photos, videos, animations, and a small explanation in the form of text.** To go to AR, press "Play AR". For go to the next panel, press "Next".
Quiz 	**The quiz contains statements that have several parts that are missing. The missing parts are filled in with the answers provided.** After all the quizzes have been answered correctly, then the "OK" button will function.
Reflection 	**Reflection contains a reflection button that will take the user to a Google form related to application use.** To return to Materials, press the "OK" button.

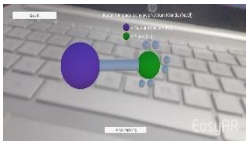
Self-Evaluation

Self-evaluation, where the product that has been developed is assessed by yourself. This self-evaluation is carried out after previously designing the application. This self-evaluation is carried out after realizing the plans that have been made previously. The method used in this self-evaluation is a check-list method to see the completeness of the prototype I that has been made.

The results of self-evaluation as follows in Table 2.

Table 2. Self-Evaluation Results

Page	Description
	Intro page is successfully displayed with the "START" button.
	Intro page is successfully displayed with the "Settings", "Instructions", "Profile", "Curriculum", "About Applications", and "Quit" buttons.
	Instructions page is successfully displayed with the "SELESAI" button.
	Profile successfully displayed with the "SELESAI" button.
	Curriculum successfully displayed with the scroll view in CP and "SELESAI" button.
	About Applications successfully displayed with the "SELESAI" button.
	Materials page is successfully displayed with the "Settings", "Play AR", "Isi", and

	"Refleksi" buttons.
	Play AR successfully displayed with AR buttons and the "SELESAI" button.
	Contents successfully displayed with AR buttons and the "ALL DONE" button.
	Learning materials successfully displayed with "Back" and "Next" buttons.
	Quiz successfully displayed by drop and drag object.
	Quiz "Next" button successfully displayed after all object are right arrange.
	Reflection successfully displayed with the "SELESAI" button.
	AR Page successfully displayed with the "Back", "Start Tracking", and "Stop Tracking" buttons.

Thus, the results of designing learning applications with marker-less augmented reality using the Plomp development model up to prototype stage II were successful in accordance with initial plan. The hope is that this learning application can be continued to the next stage of prototype formation.

CONCLUSION

Conclusions

Based on the preliminary research stage and the prototyping stage, it can be concluded that the interactive design of the learning application on chemical bond material was successful and ran as expected. The design of the learning application runs well using the Plomp development model until prototype stage II is obtained. This learning application is used as a learning medium for materials that require better visualization, such as chemical bonds. This learning application with markerless augmented reality can help students understand more about chemical bond material by displaying three-dimensional objects as if they were real in front of students and also accompanied by a quiz for each sub-material**.**

Recommendations

Based on the results of the discussion that has been described, suggestions for this research: it is hoped that research for this learning application can be continued to the next stage so that the learning application with marker-less augmented reality on chemical bond material can be used and help in the learning process both at school and outside schools.

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