Development of Android-based Multimedia to Improve Student Learning Outcome in Crystal Structure Subject of Engineering Materials Course

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Abstract: The study aims to develop and evaluate the android-based multimedia for Crystal Structure subject in the Engineering Materials course. A Crystal Structure is one of the materials contained in the Engineering Materials course. The concept must be mastered well so that students can understand the subject matter being taught. Meanwhile, without being facilitated with adequate media, students experienced difficulties in the learning process. This is because the material of this Crystal Structure subject is abstract and complex. The multimedia development used the Analysis, Design, Development, Implementation, Evaluation (ADDIE) model which consists of five stages. The multimedia developed was validated by experts to assess its feasibility. Furthermore, it was implemented with experimental methods on the control group and the experimental group to find out the impact on improving student learning outcomes. The samples used in this study were 18 DPTM class A students as a control group and 18 DPTM class B students as an experimental group, with an age range of 17-20 years. The results confirm that the android-based multimedia that was developed received a very good response from users and experts. Android-based learning multimedia can facilitate students in understanding the Crystal Structure subject. This can be seen from the increase in learning outcomes in the experimental class using android-based learning multimedia with an N-gain value of 0.94 and categorized in the high category.

Keywords: android-based multimedia, crystal structure, engineering materials, learning outcome.

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1. Introduction

The Engineering Materials course is an in-depth material science course that focuses on the structure of materials. This course is contained in the curriculum of the Department of Mechanical Engineering Education (DPTM), Faculty of Technology and Vocational Education (FPTK), Universitas Pendidikan Indonesia. This course is a mandatory course that must be taken with a total of two credits which is included in the group of study program expertise courses (Komaro, 2015). This course studies the material planning, material structure, material properties, and material capabilities, as well as their application (Khabiri & Bahabad, 2019; Komaro et al., 2019), and is indispensable to support learning in further study program expertise courses, such as Advanced Engineering Materials, Mechanical Elements, and Strength of the Material.

A crystal structure is one of the important parameters in material science (Fatima et al., 2022; Fauziah & Nandiyanto, 2022; Maulidah & Nandiyanto, 2022). This makes this subject to be contained in the Engineering Materials course. A crystal structure is made up of a unit cell, a group of specially arranged atoms, which are periodically repeated in three dimensions in a lattice. To master the Crystal Structure subject, students must be able to state the relationship that occurs in each attribute of the existing concept. The concept must be mastered well so that students can understand the subject being taught. Meanwhile, without being facilitated with adequate media, students experience difficulties in the learning process because this subject is abstract and complex (Komaro et al., 2018).

Preliminary research has been conducted to find out how many students have mastered and how many students are still having difficulties in the learning process Engineering

Materials course, especially on the subject of Crystal Structure. The results of the study are shown in Table 1.

Table 1. Describes the percentage of students who master the crystal structure main subject

Assessment Type	Percentage of students who master the subject of Crystal Structure (%)			
	2016	2017	2018	2019
Mid-term	52	57	63	44
Final-term	18	25	18	42
Average	38	41	43	43

According to Table 1, in four years, the average student who mastered the subject of Crystal Structure was below 50%. This means that half of the students still have difficulty learning the subject of Crystal Structure. Even though the subject is fundamental and is needed for advanced courses that have a higher level of difficulty. Based on the importance of Engineering Materials courses, an effort is needed to solve this problem. One effort that can be done is with learning media that is not only at the theoretical level but is a practical, economical, accessible, and easy to teach (teachable) media (Azizah et al., 2022; Glorifica, 2021; Winarni & Rasiban, 2021; Sumitra et al. 2021). Efforts to meet the criteria of practical, economical, accessible, and teachable media will be pursued by manipulating theoretical models (images) into realistic models in the form of multimedia animation (Kasmana et al., 2021; Nuhu & Onojah, 2022). The use of Multimedia and Animation Media has been proven to be able to improve student learning outcomes (Putra et al., 2019).

Current technological developments provide convenience, especially in the field of Science and Technology. Innovations that continue to develop from year to year make it easier to access various information, especially in terms of learning, one of the technologies currently developing is smartphones. A smartphone is a communication device or mobile phone, which can use like a computer (Kibona & Rugina, 2015). This is an opportunity to develop learning media by utilizing Android which is very likely to be able to overcome the problems described before.

Android-based learning media is claimed to be more practical and flexible than computer-based learning media because it can be taken anywhere, is easy to access at any time, and Android smartphones are mandatory items for daily communication. The animation-based multimedia learning media has been developed but is still computer-based and the learning approach in multimedia animation is still teacher-centered. Android-based multimedia that will be developed in this study will be based on smartphones, so students can access multimedia anytime and anywhere, not necessarily while in class, and students have full control over their learning process.

The objective of this research is to develop and evaluate the Android-based multimedia in the Engineering Materials course. The android-based multimedia will use as a learning media for Crystal Structure subject in the Engineering Materials course learning process to compare with a conventional static image media in terms of PowerPoint slide deck with the expectation that it can improve student learning outcomes after the learning process

2. Method

The development model used is the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model, with the consideration that the model is suitable for multimedia development, effective, and dynamic. The ADDIE model was developed to design a learning system. The ADDIE development model has five stages or development steps as shown in Fig. 1.

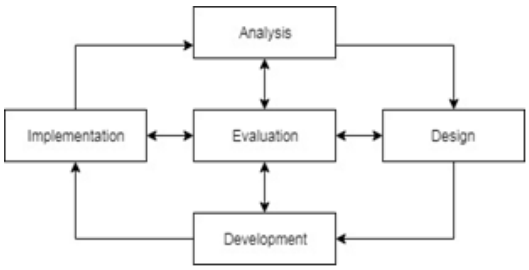

Fig. 1 ADDIE Model for Multimedia Development

2.1. Analysis

At the analysis stage, identification and analysis of the learning of Engineering Materials course are carried out and become a learning multimedia product. It was decided that the subject that will be the content of the learning multimedia is the Crystal Structure subject. This is based on data obtained from preliminary research, that in a period of four years (2016-2018), the average student who mastered the subject of Crystal Structure was below 50%, or half of the students still have difficulty in learning the subject of the Crystal Structure.

2.2. Design

In this process, a storyboard is created. The storyboard is a design in every part, from the layout, voice to the animation of the media. The storyboard is used as a reference for the development of the Android-based multimedia design.

2.3. Development

The next stage in the ADDIE model is the development stage. At this stage, we make Android-based multimedia applications and make expert judgments on the multimedia.

(i) Creating Multimedia Applications. The development stage is to produce Android-based multimedia applications that are used as media in learning. The development contains the activities of product realization. We use the Construct2 software in making android-based multimedia.

(ii) Expert Judgment. Expert judgment is the media assessment and validation stage before being tested on media users (students) in the learning process. Expert judgment is carried out by one material expert and one media expert. This judgment data is used as a basis that the content of the material in the animation media and learning materials that have been made is suitable for use in research.

The instrument used to measure the feasibility of this multimedia is a questionnaire given to the evaluator to

evaluate the multimedia animation based on Android applications from the media aspect and the learning material aspect. Giving a score on the rating scale, each answer on the instrument is given a different value weight with the following description: 4: Strongly Agree, 3: Agree, 2: Neutral, 1: Disagree, and 0: Strongly Disagree. After the judgment indicators are judged by the expert, the scores obtained are then added up to obtain a total score, and calculations are carried out to assess the percentage of eligibility. Calculation of the percentage of eligibility using equation (1).

$$Y = \frac{P}{Q} x\ 100\% \quad (1)$$

where *Y* is the Feasibility Rate, *P* is the score obtained, and *Q* is the ideal score.

2.4. Implementation

This stage is the stage of implementing Android-based multimedia in the field to collect research data. The following are the activities that the author does at the implementation stage: (i) Give a pretest (pretest) to the Experimental group and Control group to determine student learning outcomes in the cognitive domain before being given treatment. (ii) Provide treatment (treatment) in each group. In the experimental group, Android-based Multimedia is implemented. While in the control group, PowerPoint is implemented. (iii) Give a final test (posttest) to the experimental group and control group to analyze student learning outcomes in the cognitive domain after treatment. The research location is Universitas Pendidikan Indonesia. The main subject of the research are 36 students in mechanical engineering. The samples used in this study were 18 students class A as a control group and 18 students class B as an experimental group, with an age range of 17-20 years.

2.5. Evaluation

The last stage in the ADDIE development model is the evaluation stage. The purpose of this stage is to measure the quality of the product and process before and after evaluation. We used two evaluation tools, namely questionnaires and written tests.

1) Student Learning Outcomes
   The increase in student learning outcomes in this study is a description to see the effect of animation media on increasing students' understanding. The data were taken using an objective test in the form of an essay choice. The objective test was given to the experimental group and also to the control group. Furthermore, the Normalized-gain (N-gain) analysis is used to measure the increase in student learning outcomes. The formula used for the N-gain analysis according to Hake (2002) is formula 2.
   $$Normalized\ Gain = \frac{Post\ test\ score - Post\ rest\ score}{ideal\ score - Pretest\ score} \quad (2)$$
2) User Feedback
   The response data of media users in the study is a description to assess student responses and feedback to the android-based multimedia implementation. The student response format sheet made in this study is in the form of a rating scale consisting of 10 questions regarding multimedia features and implementation.

3. Results and Discussion

3.1. Multimedia Product

The Android-based multimedia design is based on a previously developed storyboard, it contains a combination of audio-visual and computer technology (Kasmana et al., 2021), so the learning process will involve many sensory devices and long-term memory (Dewiyanti et al., 2021). This application is made with the Construct2 software and is in .apk format specifically for use on android devices. Like another software application, the first display of multimedia applications is the Main Menu. The Main Menu is displayed as shown in Fig. 2.

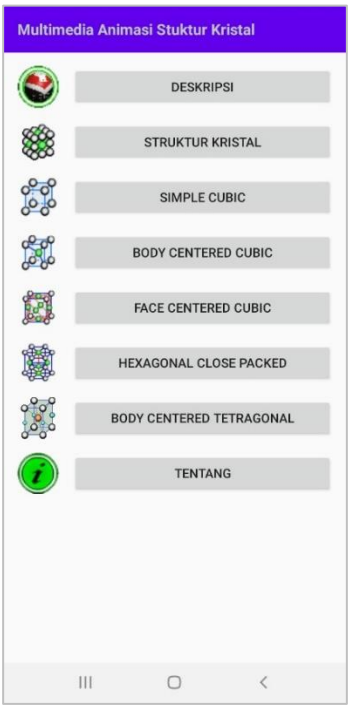

Fig. 2 Main menu screen

On the Main Menu screen, a Description menu button appears, as well as the main subject of the Crystal Structure, such as a Simple Cubic Crystal Structure menu, a Simple Cubic menu, a Body-Centered Cubic menu, a Face Centered cubic menu, a Hexagonal Close Packed menu, a Body-Centered Tetragonal menu, and a menu about applications.

To provide basic information on Engineering Materials courses, a course description page is created. Description screen will display information related to the courses to be carried out in the form of Topics Of Discussion, Time Allocation, Competency Standards, Basic Competencies, and Indicators. The course description page is displayed as shown in Fig. 3.

The main features of the developed Android-based multimedia are animation and voice. Animations and voices are used to explain the concept of an abstract Crystal

Structure so that students will more easily understand the material presented. In addition, this feature also has a Replay button to repeat animations and voice explanations. Animated features for concept explanations are shown in Fig. 4.

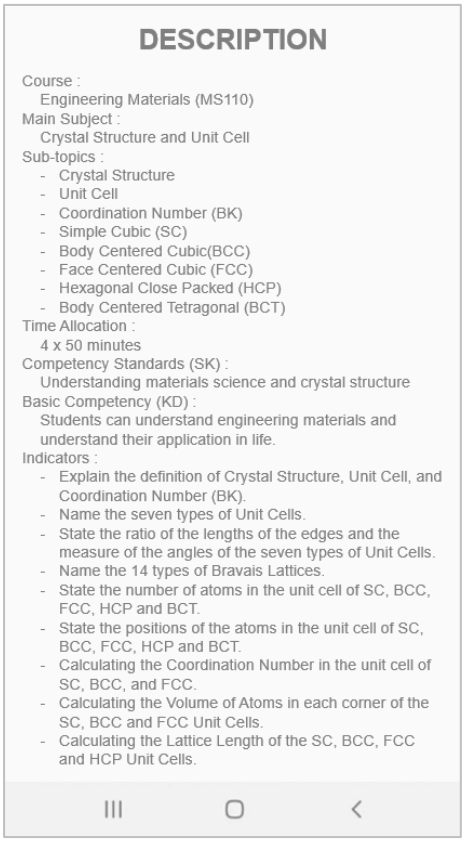

Fig. 3 Description page

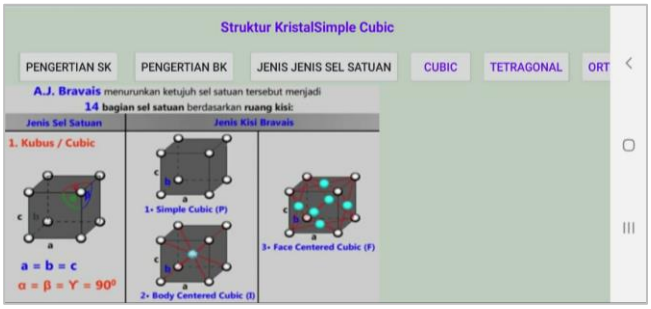

Fig. 4 Animation feature to explain the concept

In this sub-menu (shown in Figure 4), an animation in the form of images and voice appears regarding the cubic sub-menu. The animation media show the visualization of the Crystal Structure material, while the voice media explain in more detail the Crystal Structure material.

In addition to the explanation of concepts, animation and voice features are also made for calculation material. In this feature, a calculation will appear in the form of pictures, formulas, and explanations. The animation media will present the formula used for the Crystal Structure material (for example in calculating the unit cell volume), then the voice media explain the formula and its description. Animated features for calculations are shown in Fig. 5.

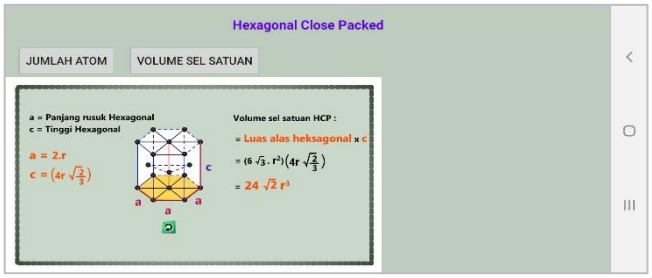

Fig. 5. Animation feature to explain formula and calculation

3.2. Expert Judgment Result

After the android-based multimedia for the Crystal Structure subject was developed, then the media was assessed by a material expert and media expert. This judgment data is used as a basis that the content of the material in the android-based multimedia and learning materials that have been made is suitable for use in the learning process. The results of expert judgment from the material expert are shown in Table 2.

Tabel 2. Material expert judgment results

	Scale					Total
	5	4	3	2	1	
QTY	3	11	2	0	0	16
Score	15	36	0	0	0	76
	Maximum Score					92
	Percentage (%)					82.60%

Based on Table 2, the percentage of the feasibility of the Crystal Structure material is 82.60%. The percentage of the feasibility of this material is then compared with the percentage of the eligibility reference. Based on the data from the judgment of material experts, it is concluded that in terms of material, the learning materials made for android-based multimedia are suitable for use in learning. After the multimedia is validated by the Material Expert, then the Android-based multimedia is validated by the Media Expert. If the animation media that has been made in terms of multimedia design is feasible to use, then the android-based multimedia that has been developed can be said to be valid in terms of multimedia design. The data on the results of the judgment by Media Experts can be seen in Table 3.

Tabel 3. Medial expert judgment results

	Scale					Total
	5	4	3	2	1	
QTY	0	2	7	2	0	11
Score	0	8	21	4	0	32
	Maximum Score					43
	Percentage (%)					74.41%

The percentage of the feasibility of android-based multimedia from the media aspect is 74.41% (Table 3). Based on the results of the media judgment and compared with the percentage of the feasibility reference, improvements were needed in the user aspect. The aspect

that has been improved is the addition of information about the Animation Media by adding the About page.

3.3. Student Learning Outcome

The level of student understanding as media users in this study is a description to see the effect of android-based multimedia on improving student learning outcomes. The data was taken using an objective test in the form of an essay choice with a total of 4 questions that have sub-points. The objective test was given to the experimental group as well as the control group as described in the methodology.

The increase in student learning outcomes for the control group and the experimental group were analyzed using the normalized gain value. The N-gain value was obtained from the comparison of the results of the pretest and posttest. The results of student learning outcomes are shown in Table 4.

Table 4 provides information that both the control group and the experimental group had 18 respondents. The average pretest score for the control group was 31.7 while the experimental group was 30.5. The average control group is 1.2 points higher than the experimental group. However, after being given treatment, the post-test results of the experimental group were 22.2 points higher than the control group. In general, the gain or difference obtained in the experimental group is 95.6 points, while for the control group it is 73.4 points. The gain is then divided by the largest possible gain to obtain an N-gain value of 0.94 for the experimental group.

Tabel 4. Medial expert judgment results

Control Group					
No	**Aspects**	**Pretest**	**Posttest**	**N-gain**	**Category**
Students		18		**0,61**	**Medium**
1	Average	31.7	73.4		
2	Highest Score	41.0	95.0		
3	Lowest Score	15.0	30.0		
Experimental Group					
No	**Aspects**	**Pretest**	**Posttest**	**N-gain**	**Category**
Students		18		**0.94**	**High**
1	Average	30.5	95.6		
2	Highest Score	42.0	99.0		
3	Lowest Score	9.0	90.0		

The use of Android-based multimedia in the learning process of Crystal Structure subject in the Engineering Materials course can improve students' learning outcomes in general. According to Table 4, the improvement of student learning outcomes from the experimental group that used Android-based multimedia is in high category improvement. It is because the Android-based multimedia is capable to animate and visualize the learning materials and help students during the learning process. In using digital technology such as Android-based multimedia, students are not only reading the text, but also watching the animation and visualization, and listening to the explanation given by the multimedia animation and voice feature, causing the mastery of the subject material to improve (Sousa & Rocha, 2019) and students more deeply understood and remembered longer because the learning process involves long term memory (Mayer, 2008; Berk, 2009).

3.4. User Feedback

Media user response data is used to find out how interesting Android-based multimedia can make it comfortable to use in the teaching and learning process. Response data were given to 18 students who had carried out the learning process in Engineering Materials using Android-based multimedia. The results of student responses, in general, are presented in Table 5.

Tabel 5. Students response results

	Scale					Total
	5	4	3	2	1	
QTY	67	101	11	0	0	179
Score	335	404	33	0	0	772
	Maximum Score					900
	Percentage (%)					85.05%

The results of student responses in Table 5 describe the average student interest in animation media as 85%, this percentage is categorized as high and interesting. Students as multimedia users respond very well to the use of Android-based multimedia in the learning process of the Crystal Structure subject in Engineering Materials courses.

With the use of Android-based multimedia, students have full control over their learning process, because students can learn the subject material anytime and anywhere. This also makes it easier for students to learn the subject material and is adjusted to their learning pace because Android-based animated multimedia has Replay and Forward features that make it easier for users to repeat the previous subject material or directly study the next subject material.

In addition, the teacher as the party who provides learning material to students is helped by the advantages possessed by Android-based multimedia during the learning process. The animation features in Android-based multimedia can help teachers convey important scientific concepts (Falvo, 2008). This makes it easier for teachers to teach concepts that exist in the subject matter of Crystal Structures so that students will more easily understand the subject matter being studied and increase students' understanding of the subject material being studied.

4. Conclusion

The android-based multimedia that was developed received a very good response from users and experts as indicated by the results of the user response questionnaire and the results of expert judgment with interesting and feasible results. Android-based learning multimedia that was developed can facilitate students in understanding the definition of Crystal Structure, coordination numbers, unit cells, and calculations in Crystal Structure subjects. This can be seen from the increase in learning outcomes in the experimental group using android-based learning multimedia with an

improvement in the high category, compared to the control group with an improvement in the medium category. From the results, it is known that the difference in the student learning outcome of the Crystal Structure material in the experimental group is superior to the control group.

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