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DEVELOPMENT OF ANDROID-BASED MULTIMEDIA APPLICATION TO OVERCOME THE DIFFICULTY OF PROBLEM-SOLVING IN THE FE-C PHASE DIAGRAM SUBJECT

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Abstract

The purpose of this study is to develop Android-based multimedia that can solve learning difficulty in the Phase Diagram subject in the Engineering Material course. The multimedia development used design-based research (DBR) method and the research used the pre-experimental method with One Group Pretest-Posttest Design. The tests carried out to 12 students who have completed the Engineering Materials course. The results stated that the application of android-based learning multimedia for the learning process in engineering materials can overcome the difficulty of several aspects in phase diagram subject, including understanding and using the correct formula, understanding the provisions of the formula, knowing the functions of the diagram axis, determining the point of a process, the connection of each related point, and determining areas in the Fe-C Phase Diagram. Android-based interactive multimedia that was developed can attract the attention of students in the delivery of material, thereby increasing their interest in learning the Fe-C Phase Diagram subject. Students' skills automatically increase due to strong curiosity and Android-based multimedia also helps students to know the steps systematically. Android-based multimedia can provide proper guidance in understanding the learning of Phase Diagram subject and can improve student learning outcomes in the high category.

Keywords: Design-based research, Engineering materials, Fe-c phase diagrams, Interactive multimedia based on android applications, Problem solving skills.

1. Introduction

Material science is the study of the relationship between material structure and material properties [1-3]. Material science is also called Engineering materials, which is a compulsory subject to be studied by students of the Department of Mechanical Engineering Education (DPTM) at Universitas Pendidikan Indonesia in Semester 1. Engineering materials must be studied by mechanical engineering students, especially in material planning [4-6].

Engineering materials is one of the courses that have its difficulties, especially in terms of calculation and problem-solving [7, 8]. The phase diagram subject in the engineering materials course is the subject with the highest difficulty level with a score of 68.8% [9]. This subject studies the types and images of the phase diagram, phase changes, phase types, phase percentages, and phase images of each alloy at each temperature change from liquid temperature to room temperature.

To support the data in previous studies, a preliminary study was conducted on 20 DPTM students in the class of 2018 to measure the level of difficulty in the learning process of the phase diagram subject. The following is a study of the difficulties faced by students in problem-solving in the Fe-C Phase Diagram material, as presented in Table 1. Based on Table 1, the majority of the DPTM students' class of 2018 have difficulties in calculating the Fe-C phase diagram, which is not understanding the formula requirements of 60%, and in phase diagram drawing, the students are difficult to determine the point of a process by 55%. Here are several causes of learning difficulties [10] because theoretical models in the form of verbal symbols and learning media that are available, not representative enough to be able to explain concepts, and ways of solving a system's problems realistically, so the possibility is not affordable (inaccessible) by students which impacts on the lack of learning experience.

Table 1. Difficulties experienced by students in the Fe-C phase diagrams subject.

Aspect	Difficulty	Student	%
Equation and Calculation	Hard to understand the formula	4	20
	The user of the formula is often confused	10	50
	Do not understand the provisions of the calculation	12	60
Fe-C Phase Diagram, Drawing	Do not understand the function of the axis	4	20
	Difficult to determine the point of a purpose that occurs	11	55
	Difficult to connect every related point	7	35
	Difficult to determine areas in the Phase Diagram	10	50

The results of the preliminary study indicate that students have difficulties in phase diagram subjects in general. Even though this subject is very important because it is one of the fundamental subjects in the field of mechanical engineering, especially

for advanced subjects such as material planning, material processing, heat treatment, and strength of the materials. Therefore, students are required to master the subject of phase diagrams in engineering materials courses as basic knowledge for more advanced fields.

Efforts to solve these problems include using learning media that are not only in theoretical discussion, but also a media with a practical, economical, and accessible feature that can describe the concept of the mechanism of metal properties changes. Efforts are made to meet the accessible criteria through theoretical manipulation (images) into a realistic model so that it can be taught (teachable) in the form of android-based multimedia on smartphones.

A smartphone is a communication device or mobile phone, which could use like a computer [11]. This has become an opportunity to develop learning media by utilizing Android [12]. Android-based learning media are claimed to be more practical and flexible compared to computer-based learning media [13] because they can be taken anywhere, easily accessed at any time, and Android smartphones are mandatory items for daily communication. Android can be supported by app, in which app can make it easy to use for users [13, 14].

Multimedia animation-based learning media had previously been made by other reports [15], but still computer-based programs. Compared to Android, computers are more difficult to access. Then there is no menu facility for making a Phase Diagram image, and the learning approach in the multimedia animation still uses the teacher-centred so that it is still less effective than the android-based learning media.

The purpose of this study is to develop the Android-based multimedia that have the capability to overcome learning difficulty in the Phase Diagram subject in the Engineering Material course. Some of the novelties in android-based multimedia developed are this application is android-based which is the most widely used operating system today [13], so this multimedia can be used anytime and anywhere. Apart from that, other advantages are students can exercise with full control over their learning activities, students are free to repeat the learning materials and choose parts of the learning materials independently. Indeed, this is useful for being utilized by a vocational school, in which this school is fulfilled by practicum [16-20]. Also, this program can be used against Covid 19 pandemic condition, making students still learning materials [18, 21-28].

2. Method

The development of android-based multimedia for this research used DBR (Design-Based Research) with the Reeves method. The Reeves method contains 4 stages, as shown in Fig. 1.

The steps of developing the android-based multimedia that must be carried out are as follows:

1. Analysis of practical problems by researchers and practitioners in collaboration.
2. Development of solutions informed by existing design principles and technological innovation.
3. Interactive cycles of testing and refinement of the solution in practice.
4. Reflection to produce “design principles” and enhance solution implementation.

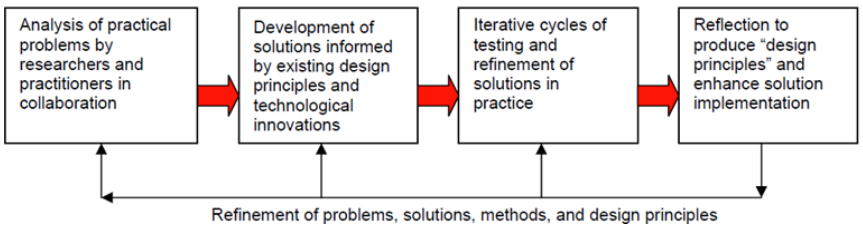

Fig. 1. Four Steps of Reeves' DBR Model.

The feasibility of the Android-based multimedia applications in this study was measured using expert judgment from material experts and media experts. This process aims to find out the strength and weaknesses of multimedia so the improvements can be made to find the results of assessments that are suitable for use as learning media. Material experts and media experts fill out the assessment questionnaire using a rating scale as in Table 2.

Table 2. Rating scale guide.

Score	Explanation
0	Strongly Disagree
1	Disagree
2	Neutral
3	Agree
4	Strongly Agree

The application of android-based multimedia in this research used a pre-experimental method with one group pretest-posttest design. In this study, the tests were carried out twice, before and after treatment. I these tests, there are some primary aspects included in the phase diagram subject, such as understanding and using the correct formula, understanding the provisions of the formula, knowing the functions of the diagram axis, determining the point of a process, the connection of each related point, and determining areas in the Fe-C Phase Diagram aspect. The test done before getting treatment is called a pretest. The pretest was given to the experimental class ($Y1$). After the pretest, the treatment is given in the form of the application of android-based multimedia of Fe-C Phase Diagram on the learning process (X). At the final stage, the posttest ($Y2$) was conducted to measure the increase in learning outcomes using android-based multimedia. The research diagram of the one-group pretest-posttest design method according to Nandiyanto et al. [29] is as follows in Table 3:

Table 3. One group pretest-posttest design.

Pretest	Independent Variable	Posttest
$Y1$	X	$Y2$

To analyse the data, the N-Gain test was used in this research to measure the improvement in student learning outcomes. The formula used for the N-Gain Test:

$$< g > = \frac{T_2 - T_1}{S_m - T_1} \quad (1)$$

where: <g> is the normalized gain, T_1 is the pre-test score, T_2 is the post-test score, and S_m is the maximum score.

3. Results and Discussion

Android-based multimedia for the Fe-C Phase Diagram subject was developed using Unity 3D software with a resolution of 1280 x 720 pixels. This software was chosen because it has a relatively small size, easy to operate, and the resulting product can be operated on all Android operating systems because it uses the **apk* file format.

The development process of android-based multimedia for the Fe-C Phase Diagram begins with the identification of the learning material. Then proceed to the design stage in compiling the storyboard as an overview of the development of android-based learning multimedia. Based on the storyboard, the display will be presented on multimedia applications based on android application learning.

Figure 2 shows the display of the Android-based multimedia Main Menu. In the Main Menu, several components have been designed on the storyboard, such as Instructions for Use, Learning Objectives, Application Specifications, Preface, and Developer Profile. The main subject display that will be presented on multimedia applications is as follows:

Fig. 2. Android-based multimedia for Fe-c phase diagram.

In Fig. 3, we can see the main display of the phase diagram subject, especially the calculation features. There is a Diagram section side by side with the Calculation formula and its phase images. The display is the result of a design that has been adapted to the reference material of the phase diagram and storyboard.

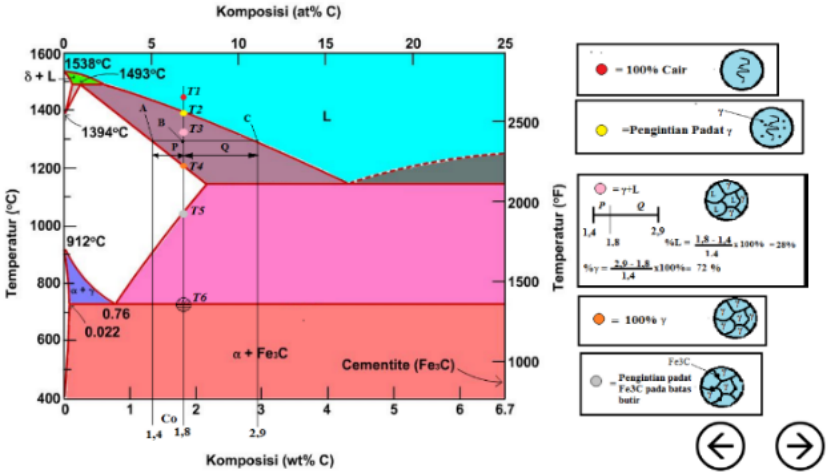

Fig. 3. Calculation feature in android-based multimedia for Fe-c phase diagram.

The feasibility of the android-based multimedia is known by testing by experts so that the multimedia produced is suitable for use in the learning process. The testing process was conducted by a material expert and a media expert by using assessment instruments and using rating scale assessment. After testing by the material and media experts, the material was declared feasible without revision with an average percentage of 90.26 % (Very Feasible). Then the multimedia is declared feasible by making improvements, while the improvements that must be corrected include adding a developer profile and instructions for use. The results of the material expert and media expert judgment are presented in Table 4.

Based on Table 4, the average score of the Material aspect reached 90.26%, while the Media aspect reached 86.6%. Both aspects are categorized as Very Feasible and Feasible, respectively.

Table 4. Android-based multimedia judgment result.

Material Aspect	Component	%	Avg.
Learning Design	Goal Relevance	100%	90.26%
	Material Relevance	83.3%	
	Material Choice	87.5%	
Visual Communication	Text	86%	86.6%
	Layout	93.3%	
	Graphic Element	100%	
	Audio & Video	73.3%	
Use	Visibility	93.3%	
	Application Information	93.3%	
Software Engineering	Usability	80%	
	Compatibility	80%	
	Effectiveness	80%	

After the android-based multimedia is created, the multimedia is implemented to overcome the difficulty of problem-solving in the Fe-C Phase Diagram subject. This will be seen from the increase in student learning outcomes. Testing was conducted on 2018 DPTM students totalling 12 people. Improvement of learning outcomes can be seen after students carry out the pretest and posttest. The pretest is done to know the learning outcomes before being given treatment using android-based multimedia, and the posttest is done to find out the learning outcomes after the treatment. The pretest and posttest data are used to describe quantitatively so that conclusions can be drawn from the results of the study. The results of the pretest and posttest are shown in Table 5.

Table 5 shows that students who have been given learning using android-based multimedia in the learning process reach an average score of 87.08 from 12 students, compared to the pretest result with an average score of 18.75. The N-Gain test was conducted to show an increase in student learning outcomes. This showed that additional media can improve student comprehension [30].

Table 5. Pretest and posttest data.

Pretest		
Score (x)	**Frequency (f)**	**f.x**
0	2	0
10	3	30
20	2	40
25	1	25
30	2	60
35	2	70
Total	12	225
Average	18.75	
Posttest		
Score (x)	**Frequency (f)**	**f.x**
80	3	240
85	1	85
90	8	720
Total	12	1045
Average	87.08	

The N-gain data shows the improvement in student learning outcomes after the application of android-based multimedia is in the high category at some aspects, including understanding and using the correct formula, understanding the provisions of the formula, knowing the functions of the diagram axis, determining the point of a process, the connection of each related point, and determining areas in the Fe-C Phase Diagram. The research data obtained shows that there is an effect of the application of Android-based multimedia on problem-solving skills in students. This can be proven by the N-Gain data which shows a score of 0.84, where the value indicates that the results are included in the high category.

The data also shows that the increase in N-gain is 0.84, which indicates that learning outcomes using android-based multimedia applications increase by 84%. In comparison, the learning outcome improvement is higher than using desktop-based multimedia animation with N-Gain obtained by 0.81 or with an increase of 81%. This means that the android-based multimedia can help students in the

learning process of Fe-C Phase Diagram subject. The result is similar to the previous research conducted by Ismail [31] who found that smartphone-based interactive multimedia can significantly improve students' conceptual understanding compared to conventional learning models. It was because smartphone usage is not limited by space and is not focused on the classroom, this provides flexibility for students to explore their knowledge more broadly outside the classroom. In android-based multimedia, students can exercise with full control over their learning activities, students are free to repeat the learning materials and choose parts of the learning materials independently based on their pace of learning.

Based on the theory of learning media grouping, interactive multimedia is included in the media from a combination of print media, audio-visual, and computer technology. Interactive multimedia displays a combination of static and dynamic text, images or visuals, audio, and they are all controlled using a computer so that the learning process involves many sensory devices. Other characteristics possessed by the multimedia learning of the Fe-C Phase Diagram in addition to displaying the effects of animated motion, also provides the side of interaction that is built between multimedia and its users so that it can attract more the attention of students and is easy to teach. The learning approach using the student-centred allows students to better understand the material.

Android-based interactive multimedia that was developed can attract the attention of students in the delivery of material, thereby increasing their interest in learning the Fe-C Phase Diagram subject. Students' skills automatically increase due to strong curiosity and multimedia also helps students to know the steps systematically. With these advantages, Android-based multimedia has the potential to be applied to other subjects in the same field, especially in advanced subjects that have higher difficulties and various aspects [32]. With the effect of moving animation, the way the material is delivered by the narrator and in terms of the interaction built between multimedia and its users is more interesting and easier to understand by students.

4. Conclusion

Based on the analysis and discussion, it can be concluded that the application of android-based learning multimedia for the learning process of phase diagram subject in engineering materials course can overcome the difficulty of several aspects in related subjects, including 1) understanding and using the correct formula, 2) understanding the provisions of the formula, 3) knowing the functions of the diagram axis, 4) determining the point of a process, 5) connection of each related point, and 6) determining areas in the Fe-C Phase Diagram. In addition, the android-based multimedia can provide proper guidance in understanding the learning of phase diagrams subject and can improve student learning outcomes in the high category.

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References

1. Dimiduk, D.M.; Holm, E.A.; and Niezgoda, S.R. (2018). Perspectives on the impact of machine learning, deep learning, and artificial intelligence on materials, processes, and structures engineering. *Integrating Materials and Manufacturing Innovation*, 7(3), 157-172.
2. Ferguson, A.L. (2017). Machine learning and data science in soft materials engineering. *Journal of Physics: Condensed Matter*, 30(4), 043002.
3. Surjadi, J.U.; Gao, L.; Du, H.; Li, X.; Xiong, X.; Fang, N.X.; and Lu, Y. (2019). Mechanical metamaterials and their engineering applications. *Advanced Engineering Materials*, 21(3), 1800864.
4. Khabiri, M.M.; and Bahabad, M.J.A. (2019). Teaching and learning of practical skills: Learning from the pavement laboratory course. *Journal of Technical Education and Training*, 11(2), 015-022.
5. Santoso, T.I.; and Hassan, R. (2018). Developing k-workers'competencies framework for undergraduate university students. *Journal of Technical Education and Training*, 10(2), 62-70.
6. Odeh, S.; McKenna, S.; and Abu-Mulaweh, H. (2017). A unified first-year engineering design-based learning course. *International Journal of Mechanical Engineering Education*, 45(1), 47-58.
7. Komaro, M.; Ariyano, A.; Suherman, A.; and Geovani, G.F. (2018). Problem solving in phase diagram of engineering material subject through animation as learning media. *MATEC Web of Conferences*, 197(2018), 12008.
8. McLaren, B.M.; Van Gog, T.; Ganoe, C.; Karabinos, M.; and Yaron, D. (2016). The efficiency of worked examples compared to erroneous examples, tutored problem solving, and problem solving in computer-based learning environments. *Computers in Human Behavior*, 55(2016), 87-99.
9. Komaro, M.; Suherman, A.; Ariyano, P.R.; Minghat A.D. (2020). Development of interactive multimedia to overcome difficulties in isomorphous binary phase diagram learning materials. *International Journal of Advanced Science and Technology*, 29(7s), 284-289.
10. Purnawan (2006). Desain model komponen pneumatik untuk media pembelajaran mekanisme komponen pneumatic. *Jurnal INVOTEC*, III(9), 116-124.
11. Kibona, I.; and Rugina, J. (2015). A review on the impact of smartphone on academic performance of students in higher learning Institution in Tanzania. *Journal of Multidisciplinary Engineering Science and Technology*, 2(4), 673-677.
12. Rosidin, U.; Kadaritna, N.; and Saputra, A. (2019). Attitude towards technology for pre-service science teachers in Indonesia: An exploratory factor analysis. *Periodico Tche Quimica*, 16(3), 866-876.
13. Thapwiroch, K.; Kumlue, A.; Saoyong, N.; Taprasan, P.; and Puengsungewan, S. (2021). Easy-mushroom mobile application using the Internet of Things (IoT). *Indonesian Journal of Educational Research and Technology,* 1(1), 1-4.
14. Albion, L.; Kaira, M.R.; Tawami, T.; Fairuz, D.A.; and Maulana, H. (2021). Designing english education game application for early childhood. *ASEAN Journal of Science and Engineering Education,* 1(2), 117-124.

15. Kasmana, K.; Dewi, A.C.; Hermiyah, M.; Asifa, V.; Maulana, H. (2021). Designing multimedia applications for nutrition education and managing stress. *Indonesian Journal of Teaching in Science*, 1(1), 27-38.
16. Rosina, H.; Virgantina, V.; Ayyash, V; and Dwiyanti, V. (2021). Vocational education curriculum: Between vocational education and industrial needs. *ASEAN Journal of Science and Engineering Education*, 1(2), 105-110.
17. Handayani, M.N.; Ali, M.; Wahyudin, D.; and Mukhidin, M. (2020). Green skills understanding of agricultural vocational schoolteachers around West Java Indonesia. *Indonesian Journal of Science and Technology*, 5(1), 21-30.
18. Sangsawang, T. (2020). An instructional design for online learning in vocational education according to a self-regulated learning framework for problem solving during the CoViD-19 crisis. *Indonesian Journal of Science and Technology*, 5(2), 283-198.
19. Ana, A. (2020). Trends in expert system development: A practicum content analysis in vocational education for over grow pandemic learning problems. *Indonesian Journal of Science and Technology*, 5(2), 246-260.
20. Al-Najar, H.; and Hamarneh, B.E. (2019). The effect of education level on accepting the reuse of treated effluent in irrigation. *Indonesian Journal of Science and Technology*, 4(1), 28-38.
21. Mulyanti, B.; Purnama, W.; and Pawinanto, R.E. (2020). Distance learning in vocational high schools during the covid-19 pandemic in West Java province, Indonesia. *Indonesian Journal of Science and Technology*, 5(2), 271-282.
22. Hashim, S.; Masek, A.; Abdullah, N.S.; Paimin, A.N.; and Muda, W.H.N.W. (2020). Students' intention to share information via social media: A case study of COVID-19 pandemic. *Indonesian Journal of Science and Technology*, 5(2), 236-245.
23. Hernawati, D.; and Nandiyanto, A.B.D. (2021). The use of learning videos in order to increase student motivation and learning outcomes during the covid-19 pandemic. *ASEAN Journal of Science and Engineering Education*, 1(2), 77-80.
24. Nasution, A.R.; and Nandiyanto, A.B.D. (2021). Utilization of the google meet and quiz applications in the assistance and strengthening process of online learning during the COVID-19 pandemic. *Indonesian Journal of Educational Research and Technology*, 1(1), 31-3
25. Huwaidi, F.; Nandiyanto, A.B.D.; and Muhammad, N. (2021). The urgency of online learning media during the Covid-19 pandemic at the vocational school in Indonesia. *Indonesian Journal of Educational Research and Technology*, 1(2), 35-40
26. Maryanti, R. (2021). Assessment of mathematical abilities of students with intellectual disabilities during the COVID-19 pandemic. *Indonesian Journal of Community and Special Needs Education*, 1(2), 47-52
27. Ganesha, P.; Nandiyanto, A.B.D.; and Razon, B.C. (2021). Application of online learning during the Covid-19 pandemic through zoom meeting at karya mekar elementary school. *Indonesian Journal of Teaching in Science*, 1(1), 1-8.
28. Ramdhani, T.; Nandiyanto, A.B.D. (2021). The use of Whatsapp social media as reinforcement online learning during the COVID-19 pandemic. *Indonesian Journal of Multidisciplinary Research*, 1(1), 107-112.

29. Nandiyanto, A.B.D.; Raziqi, G.Y.; Dallyono, R.; and Sumardi, K. (2020). Experimental demonstration for enhancing vocational students' comprehension on heat transfer through conduction and radiation of light bulb. *Journal of Technical Education and Training*, 12(3), 189-195.
30. Hidayat, D.S.; Rahmat, C.; Fattah, N.; Rochyadi, E.; Nandiyanto, A.B.D.; and Maryanti, R. (2020). Understanding Archimedes law: What the best teaching strategies for vocational high school students with hearing impairment. *Journal of Technical Education and Training*, 12(1), 229 – 237.
31. Ismail, A. (2017). Penerapan multimedia interaktif berbasis smartphone untuk meningkatkan pemahaman konsep mahasiswa pada mata kuliah fisika dasar. *Jurnal Teknologi Pendidikan dan Pembelajaran*, 2(2), 114-124.
32. Firmansyah, D.B.; and Rahmawati, R.S. (2018). Penggunaan media ajar berbasis multimedia dalam pembelajaran kanji. *Japanedu: Jurnal Pendidikan dan Pengajaran Bahasa Jepang*, 3(1), 1-10.