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IS IT PRACTICAL DIGITAL LEARNING APPLICATION FOR LEARNING 3D GRAPHIC DESIGN BASED ON AUGMENTED REALITY?

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ABSTRACT
Learning Graphic Design requires a high level of visualization, especially for design concepts or 3D interior design. If this material is only taught through guided practice in class, the learning outcomes will certainly not be optimal, especially for vocational graduates in the current digital era. The research aims to test the practicality of digital learning applications based on augmented reality technology as a learning medium for 3D interior graphic design. The type of research is Research and Development (R&D) with the Borg and Gall Method, data collection techniques using Likert scale questionnaires, applications built using Blender for modelling, Unity 3D for Augmented Reality Implementation, Android Studio for designing applications, Firebase for database storage, and Fiqma to design the interface design. This research produces a digital learning application that is used for learning 3D interior graphic design which is equipped with learning needs such as classrooms, and communication rooms and is based on Augmented Reality technology so that the resulting interior design objects can be displayed in real-time. Aiken's V formula is used to test the practicality of digital learning applications. The research results showed that the average Aiken's V score from lecturers was 85.22% in the practical category, and students in the small group test was 82.96% and students in the large group test was 83.04% in the practical category. So, it can be concluded that the use of the DiGi.AR application based on Augmented Reality is good and practical for learning 3D graphic design.
Keywords: *DiGi.AR, Application, Augmented Reality, 3D Interior Graphic Design, Digital Learning*

1. Introduction

The current development of information and communication technology means that the learning process can be carried out from anywhere and at any time with Android-based learning (Ningsih & Adesti, 2020). Android is a new generation of Linux-based mobile platforms that includes an operating system, middleware, and applications (Falode et al., 2022). It is hoped that Android-based learning media can raise students' learning motivation and enable students to learn independently according to their abilities from anywhere and at any time (Ulfa et al., 2017).

The use of learning media in the current digital era, of course, cannot be separated from technological developments, such as Augmented Reality which really supports graphic design learning in order to display 3D design objects virtually, realistically, and in real-time so that learning becomes effective and fun (Elfeky & Elbyaly, 2021). Nowadays, there are more and more varied learning media used, which essentially functions as a tool to help lecturers interact with students in the learning process to make learning interesting and fun (Diah et al., 2021). Apart from that, the digital learning revolution also continues to develop, combining various scientific fields with technology, in this research, an Augmented Reality-based learning application was created which was named the DiGi.AR Application (Supriyanto et al., 2023).

This application is expected to help lecturers in the learning process, because based on current conditions, the learning process is still limited to using lecture methods, guided practice, and students only try to memorize the steps in making design objects so that learning becomes ineffective (Enzai et al., 2020).

Besides that, the ratio of lecturers who teach is 1:35 and the duration of learning time for practical learning is still insufficient because it is only 3 hours per week. Apart from that, in graphic design learning practice, lecturers only use textbooks that contain material with several

images, and other media such as Mobile (cel lphone) media has not been utilized (Poláková, 2022). In fact, lecturers and students already have Android-based cell phones but have not used them to support the learning process (Triadiarti et al., 2021). In the current digital era, technological advances need to be utilized to support the learning process (Haleem et al., 2022), so that learning becomes effective, interesting, and fun (Akbar, 2016).

Based on the explanation above, technological advances such as Android and Augmented Reality can be a solution by creating a mobile-based learning application. In 3D interior graphic design courses (Chen et al., 2011) learning needs to be supported by mobile media that can be practically used at any time and from anywhere so that learning can be done independently (Mayefis, 2022). Students can repeat material on making design objects that they find difficult by watching the video tutorials provided in the application so that students' design skills can continue to be trained using the DiGi.AR application. Furthermore, the use of technology can really be felt in the world of education (Haleem et al., 2022).

2. Literature Review

This research product is implemented for learning 3-dimensional interior graphic design, by utilizing developments in digital technology as a learning medium. This application contains material in the form of video tutorials, creating design objects using the blender program, where the output can be displayed in the form of Augmented Reality, so this becomes something interesting and fun for students. All learning processes carried out in the classroom can also be carried out through this application, such as student attendance checks, presentation of material, question and answer or discussion processes, and giving or collecting assignments. The application is designed like E-learning which facilitates all learning needs so that students who previously did not fully understand the material in the classroom can repeat the explanation of the material again by following the video tutorials available in the application. This mobile application is also real-time, so students can use it at any time and from anywhere.

Previous research has been conducted on the utilization of Augmented Reality technology in 3D visualization (Kusumaningrum et al., 2019). The research concluded that Augmented Reality technology is able to provide reliable information and can directly integrate with the generated 3D objects. The difference in this research is that the generated 3D objects are buildings to introduce school environment.

Another related study is on "Development of Interactive Multimedia based on Augmented Reality to improve students' skills" (Syawaludin et al., 2019). The research results indicated that the development of media products determines learning indicators, and students' critical thinking using Augmented Reality-based learning media is better than before using it. The difference with this research is that the learning media used is interactive multimedia based on Augmented Reality.

Furthermore, research on "Development of Augmented Reality for innovative learning in education" has been conducted (Enzai et al., 2020). The research results stated that students' interest and motivation in the learning process increased compared to before, and AR can overcome financial and space constraints related to learning equipment and devices.

3. Research Methods

The method used in this research is Borg and Gall. This method was chosen because it has a flexible, systematic procedure, and provides opportunities for researchers to make adjustments to stages in development (Kencana et al., 2022). The Borg and Gall method has several stages in product development, these stages are depicted in Figure 1 (Bentri & Hidayati, 2022).

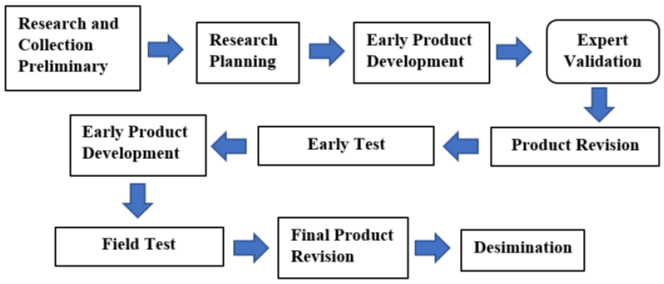

Fig. 1. Stages of the Borg & Gall Development Method

Based on the picture above, from 10 stages of the development method, stages were combined for efficiency (Aka, 2019). This agrees with Borg and Gall that this development stage may be reduced or combined in several stages for efficiency and to reduce the scale of the project being developed (Muhardi et al., 2017). The Borg and Gall method which consists of 10 stages is simplified into 5 stages, like the simplification carried out by the Center for Policy and Innovation Research (Rini et al., 2020). The Borg and Gall stage is reduced to five stages, namely: a) product analysis, b) product development, c) validation and revision, d) small-scale trials and revisions, e) large-scale trials and final products.

3.1. Analysis Stage

This stage starts with collecting the information needed to develop an Augmented Reality-Based Digital Learning Application for 3D Graphic Design Learning, is this application really needed for graphic design learning? The extent of the needs was explored first by distributing a questionnaire to 30 students who had studied graphic design and 5 lecturers teaching graphic design courses. From the questionnaire distributed, results were obtained as in Figures 2 and 3.

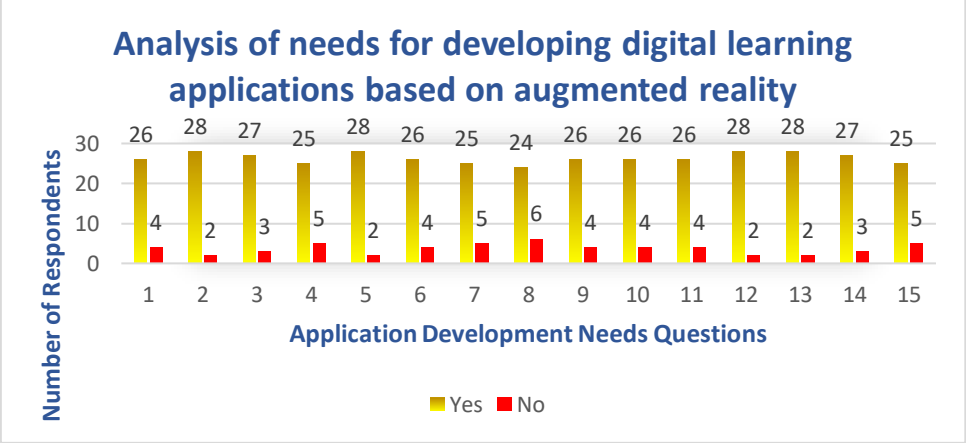

Fig. 2. Results of Needs Analysis of 30 Students

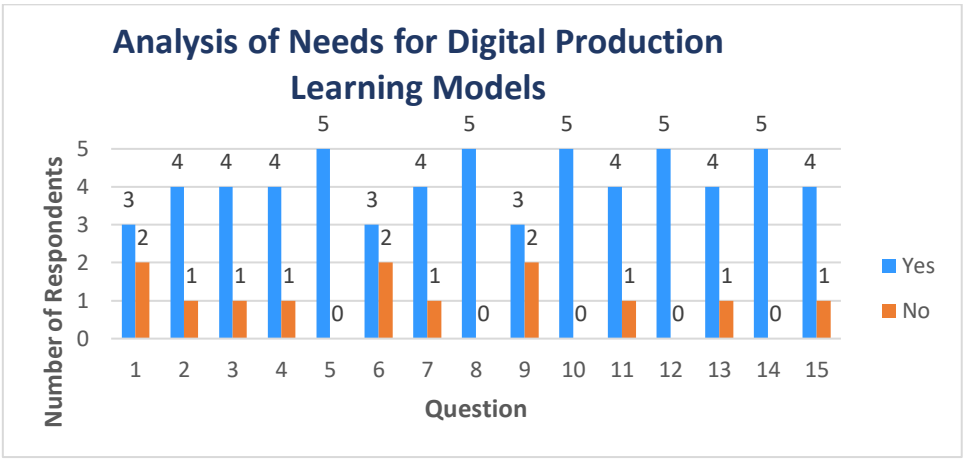

Fig. 3. Results of Needs Analysis from 5 Lecturers

From the two images above, it can be concluded that there is a need for an Augmented Reality-based digital learning application that is used for learning 3D Graphic Design so that learning can be done better, more interestingly, and practically.

3.2. Product Development

At this stage, the development of a digital learning application with the name DiGi.AR application based on Augmented Reality, which functions as a virtual learning medium (Cai, 2016), is carried out in Graphic Design courses in higher education. This application is equipped with Augmented Reality (AR) technology so that all 3D Graphic Design Objects that students have previously created using the Blender application, can be displayed in their original form virtually and in real-time (Hamzah et al., 2021). This Augmented Reality creation and design skill, of course, is a basic ability for students to be able to become digital entrepreneurs in the field of graphic design. In addition, combined with digital marketing skills, those skills would be beneficial to market their design products virtually on social media, as is done by professional interior companies such as IKEA, Jeimart, Informa, and others (Huda, 2021). This application is in the form of a master.apk file which runs on the Android platform and requires Android smartphone device specifications: Android level 5.0 "Lollipop", ROOM 500 MB, RAM 1024 MB and camera (Hutchinson et al., 2022), the application usage flowchart can be seen in Figure 4.

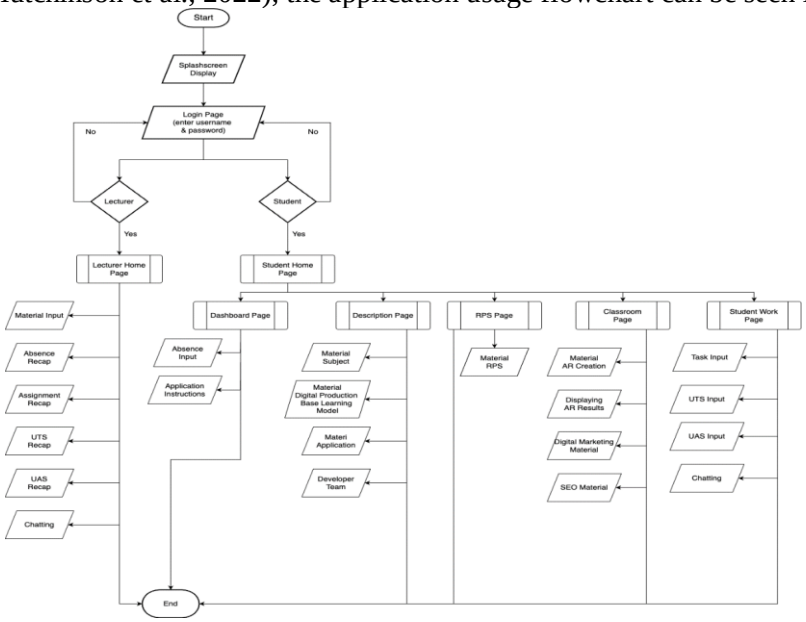

Fig. 4. Flowchart of Using the DiGi.AR Application

3.3. Validation and Revision

After creating the DiGi.AR application, validation, and revisions are then carried out by validators/experts so that the product created meets all the needs and feasibility of a learning application (Maulidya et al., 2022). The application was demoed to 5 experts, they immediately tried and tested it using a smartphone, and then provided some input for improving the DiGi.AR application. Validation is carried out by filling out a validation instrument that contains several assessment aspects, namely: device engineering aspects, design/appearance, and visual communication aspects (Antonides & Hovestadt, 2021). The validator assessment results can be seen in Table 1.

Table 1 - Validation assessment of the DiGi.AR application based on Augmented Reality

No	Indicator	Aiken's V	Category
1	The DiGi.AR application is effective and efficient as a medium for learning graphic design by utilizing the latest technology (Augmented Reality)	0,9	Valid
2	The Digi.AR application is reliable as a graphic design learning application	0,75	Valid
3	The DiGi.AR application can be managed easily	0,8	Valid

4	Easy to use and simple to operate	0,85	Valid
5	Android based application so it is easy for further development	0,85	Valid
6	The DiGi.AR application can be installed/run on various existing hardware and software	0,85	Valid
7	Integrated learning program packaging that is easy to execute	0,9	Valid
8	Complete learning media program documentation: application instructions, description, RPS, Classroom, and Student Work	0,75	Valid
9	The application design is attractive and user friendly	0,8	Valid
10	Splash Screen / initial display shows the characteristics of the application	0,95	Valid
11	The layout of the elements in the application is precise and according to needs	0,75	Valid
12	The interface is consistent on all application pages	0,9	Valid
13	Use appropriate and attractive icons and colors	0,7	Valid
14	The text display in the application is clear and readable	0,8	Valid
15	The text display is creative and consistent so that the message is in line with the application's objectives	0,8	Valid
16	The video and audio in the application are interesting and meet your needs	0,75	Valid
17	The visuals and layout of the application are attractive and easy to use	0,85	Valid
18	Interactive application layout so that the learning process runs well	0,85	Valid
	Rata-rata	0,81	Valid

Source: Primary Data 2023 (processed)

Based on the validation test assessment of the DiGi.AR application, an Aiken's V value of 0.81 was obtained. The results of Aiken's V calculation range from 0 to 1, for results ≥ 0.667 it is stated in the fairly high and valid category. For the validity, it refers to the provisions of Table 2.

Table 2. Validity Category Criteria

Category	Qualification
0,67 – 1,00	Valid
≤ 0,66	Invalid

Source: (Raschka, 2018)

The closer the validation results are to 1, the higher the coefficient can be interpreted. The V value of 0.81 is stated in the valid category.

3.4. Small Group Test (Practicality)

Practicality data for the small test was obtained from 10 students, with 23 practicality instruments being tested. The test results were used as a basis for determining the level of practicality of the DiGi.AR Application. The answer choices are determined from several categories, namely: strongly agree, agree, fair, disagree, and strongly disagree (Putri et al., 2019). The practicality of the product/application is based on the following provisions: (Shah & Ali, 2019)

a. Answer score criteria include: 5 = Strongly Agree, 4 = Agree, 3 = Fair, 2 = Disagree, 1 = Strongly Disagree

b. Determining the average obtained by adding up the values obtained from various indicators

c. Giving practicality value using the formula:

$$NA = \frac{S}{M} \text{ x } 100\%$$

Information :

NA = Final Score

S = Score obtained

M = Total Score

Based on the practicality value, the level of practicality is then grouped as in Table 3.

Table 3. Practicality Categories

No	Achievement Rate (%)	Category
1	86 – 100	Very Practical
2	76 – 85	Practical
3	60 – 75	Fair
4	55 – 59	Less Practical
5	0 – 54	Impractical

Source : (Astutik & Prahani, 2018)

Practicality analysis using the Aiken's V formula with the formula: (Asda et al., 2022)

$$V = S / [n*(c-1)], \text{ where } S = \sum ni\ (r-lo)$$

Information :
V = Aiken's validity index
ni = number of experts who chose criterion i,
r = i-th criterion,
lo = lowest rating,
n = number of all experts,
c = number of ratings/criteria

The results of student assessments of the DiGi.AR application which will be used as a learning medium for 3D Graphic Design can be seen in Table 4.

Table 4. Practicality of the DiGi.AR Application by Small Group Students

No	Respondents / Students	Practicality Rate (%)	Category
1	Respondents 1	86,09	Strongly Practical
2	Respondents 2	85,22	Practical
3	Respondents 3	92,17	Strongly Practical
4	Respondents 4	77,39	Practical
5	Respondents 5	84,35	Practical
6	Respondents 6	78,26	Practical
7	Respondents 7	75,65	Fair
8	Respondents 8	81,74	Practical
9	Respondents 9	80,87	Practical
10	Respondents 10	87,83	Strongly Practical
	Average (%)	82,96	Practical

Source: Primary Data 2023 (processed)

Based on the table above, it is known that the results of the small group practicality test were 82.96 in the Practical category in accordance with Purwanto (2010) (Asrizal et al., 2021), which stated that the range between 76-85 was interpreted in the Practical category.

3.5. Large Group Test (Practicality)

After the small test was carried out, it was continued with large-scale practical testing to determine the usability of the DiGi.AR application which will be used as a learning medium for 3D Graphic Design. Large-scale practicality test data was obtained from 5 lecturers and 28 students, which can be seen in Table 5 and Table 6.

Table 5 - Practicality of the DiGi.AR Application by Lecturers

No	Statement Items	Lecturer					Amount	%	Information
		1	2	3	4	5			
1	Statement 1	5	5	4	4	3	21	84,0	Practical
2	Statement 2	4	5	5	3	5	22	88,0	Very Practical
3	Statement 3	5	4	3	5	4	21	84,0	Practical
4	Statement 4	5	4	5	5	4	23	92,0	Very Practical
5	Statement 5	4	5	4	4	3	20	80,0	Practical
6	Statement 6	4	3	4	5	5	21	84,0	Practical
7	Statement 7	5	5	5	4	4	23	92,0	Very Practical
8	Statement 8	4	3	5	5	3	20	80,0	Practical
9	Statement 9	5	5	4	4	5	23	92,0	Very Practical
10	Statement 10	5	4	5	4	3	21	84,0	Practical
11	Statement 11	4	4	3	4	5	20	80,0	Practical
12	Statement 12	5	4	4	5	4	22	88,0	Very Practical
13	Statement 13	4	3	4	5	4	20	80,0	Practical
14	Statement 14	4	4	3	4	5	20	80,0	Practical
15	Statement 15	5	5	3	4	4	21	84,0	Practical
16	Statement 16	5	4	4	3	5	21	84,0	Practical
17	Statement 17	4	5	5	5	4	23	92,0	Very Practical
18	Statement 18	4	5	5	4	4	22	88,0	Very Practical
19	Statement 19	4	5	4	4	3	20	80,0	Practical
20	Statement 20	5	4	4	5	5	23	92,0	Very Practical
21	Statement 21	5	4	4	3	4	20	80,0	Practical
22	Statement 22	4	5	4	5	5	23	92,0	Very Practical
23	Statement 23	4	5	4	3	4	20	80,0	Practical
	Amount	103	100	95	97	95	490		Very less
	Average	2,86	2,78	2,64	2,69	2,64	13,61	85,22	Practical

Source: Primary Data 2023 (processed)

Table 6 - Practicality of the DiGi.AR Application by Large Group Students

No	Respondents /Students	Practicality Value (%)	Category
1	Respondents 1	86,96	Strongly Practical
2	Respondents 2	83,48	Practical
3	Respondents 3	85,22	Practical
4	Respondents 4	78,26	Practical
5	Respondents 5	86,09	Strongly Practical
6	Respondents 6	78,26	Practical
7	Respondents 7	75,65	Fair
8	Respondents 8	82,61	Practical
9	Respondents 9	82,61	Practical
10	Respondents 10	86,09	Strongly Practical
11	Respondents 11	85,22	Practical
12	Respondents 12	91,30	Strongly Practical
13	Respondents 13	77,39	Practical
14	Respondents 14	84,35	Practical
15	Respondents 15	80,00	Practical
16	Respondents 16	75,65	Fair
17	Respondents 17	82,61	Practical
18	Respondents 18	82,61	Practical
19	Respondents 19	86,09	Strongly Practical
20	Respondents 20	85,22	Practical
21	Respondents 21	92,17	Strongly Practical
22	Respondents 22	86,09	Strongly Practical
23	Respondents 23	85,22	Practical
24	Respondents 24	80,00	Practical
25	Respondents 25	73,91	Fair
26	Respondents 26	83,48	Practical
27	Respondents 27	81,74	Practical
28	Respondents 28	86,96	Strongly Practical
	Average	83,04	Practical

Source: Primary Data 2023 (processed)

The practicality of applications from large groups of lecturers and students with an average percentage of 85.22 and 83.04% respectively in the Practical category, so it can be concluded that the DiGi.AR application based on Augmented Reality is practically used as a learning medium in 3D graphic design courses

4. Results and Discussions

After carrying out the stages of the Borg and Gall Method as described above, and revising the application from experts, a practical Augmented Reality-based DiGi.AR application was produced that can be used for learning 3D graphic design. This Digital Learning application can help the virtual learning process (Veletsianos et al., 2021) because it provides all the needs of the learning process starting from course descriptions, applications, RPS, teaching materials in the form of text and video tutorials, classrooms, student work, and communication facilities in the form of chat which can be accessed and carried out on the application DiGi.AR.

The DiGi.AR application was created to increase student interaction in learning, through digital-based learning (Liono et al., 2021). Augmented Reality technology is combined in the application so that the 3D design results produced by students during the learning process can be displayed directly virtually and in real-time using Android smartphones, so this is something that is interesting for students (Bahuguna et al., 2018). Moreover, students are not only skilled in 3D design but also have skills in utilizing the latest technology today, namely Augmented Reality. This digital application can be used anywhere and at any time so that the learning process can be carried out flexibly.

This research has limitations such as there is no video conference facility that allows lecturers and students to interact directly so that learning becomes more interactive. However, overall, the DiGi.AR application is very good and complete. It can be used as a digital learning medium for 3D graphic design courses.

The novelty of this research is a digital learning application for graphic design learning that can directly display 3D interior design objects in the form of Augmented Reality. The overall appearance of the application can be seen in Figure 5 to Figure 11 below.

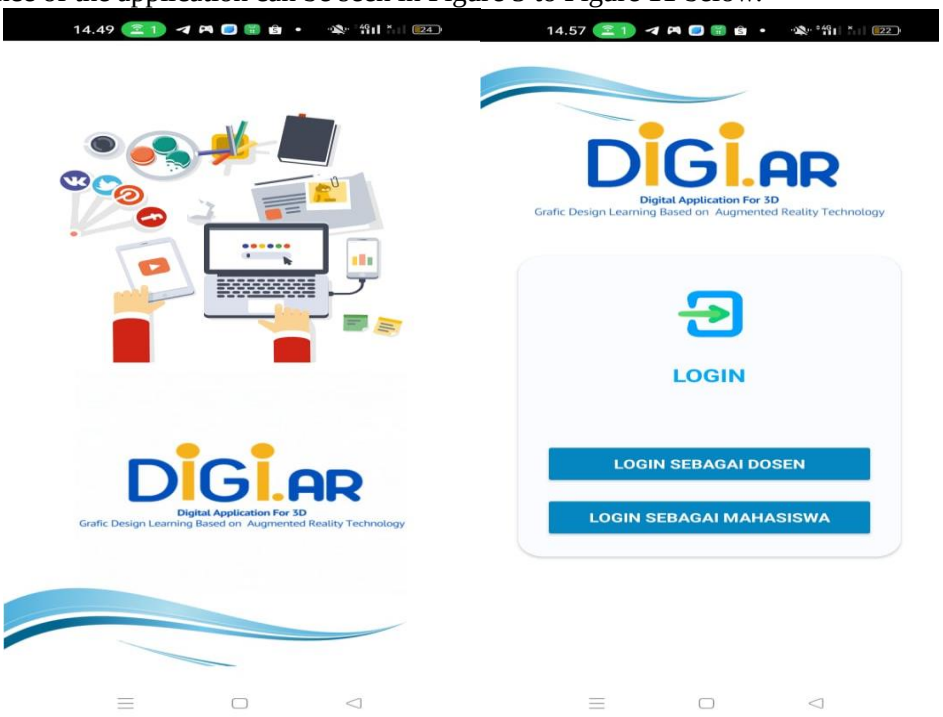

Fig. 5. Splash Screen And Main Page Of The Digi.AR Application

This page displays the application name and icon as a marker or characteristic of the application. After that, you will be directed to the login page using the username and password that was previously registered.

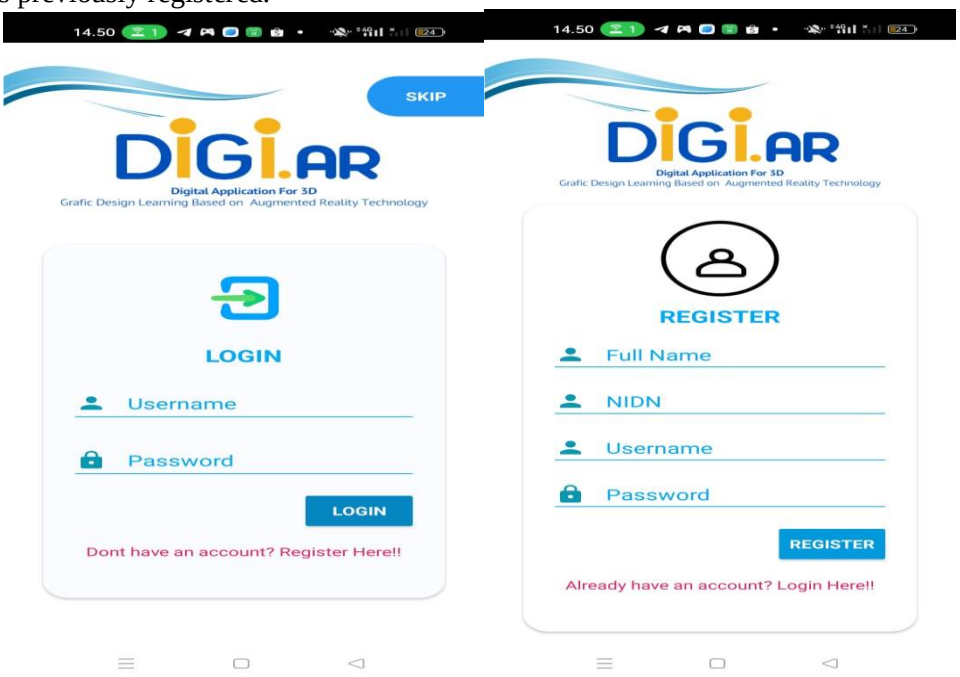

Fig. 6. Register Page

To register an account as a user, a form is provided: full name, NPM, username, and password. A username and password are useful for logging in to the application, but if you already have an account, the user can log in directly.

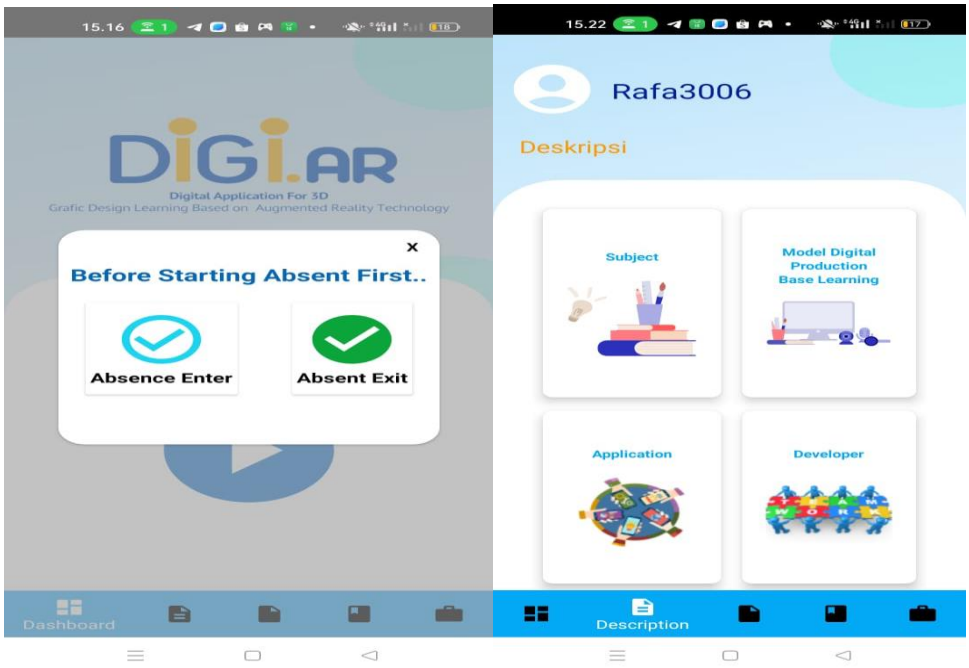

Fig. 7. Dashboard and Description page

Users are required to fill in the attendance sheet first, after that they can see the application usage guide by selecting the play image, the application usage guide is provided in the form of a video tutorial to make it easier for users to understand how to use the application. Next, the description page contains a menu: subject (3D graphic design course), application, and developer.

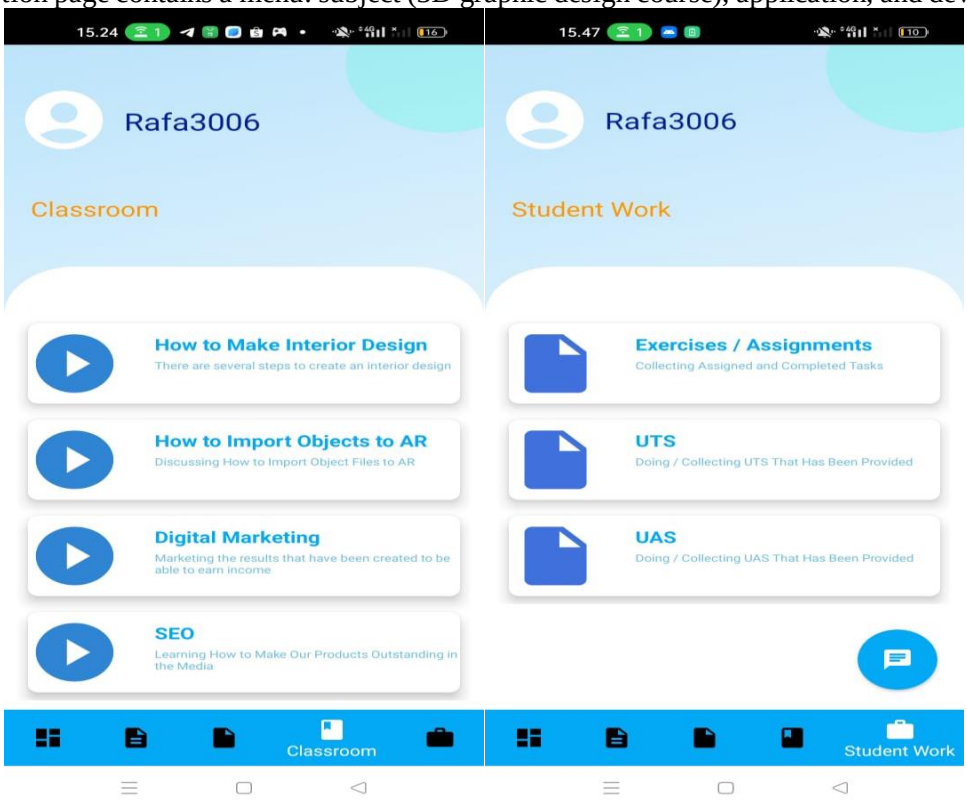

Fig. 8. Classroom and Student Work pages

The Classroom menu contains all learning needs and materials in the form of video tutorials. The Student Work page is provided to upload all student assignments and exercises. In Classroom, there is a menu option How to Import Object to AR which functions to display all interior design objects that have been created in Augmented Reality form as in Figure 9.

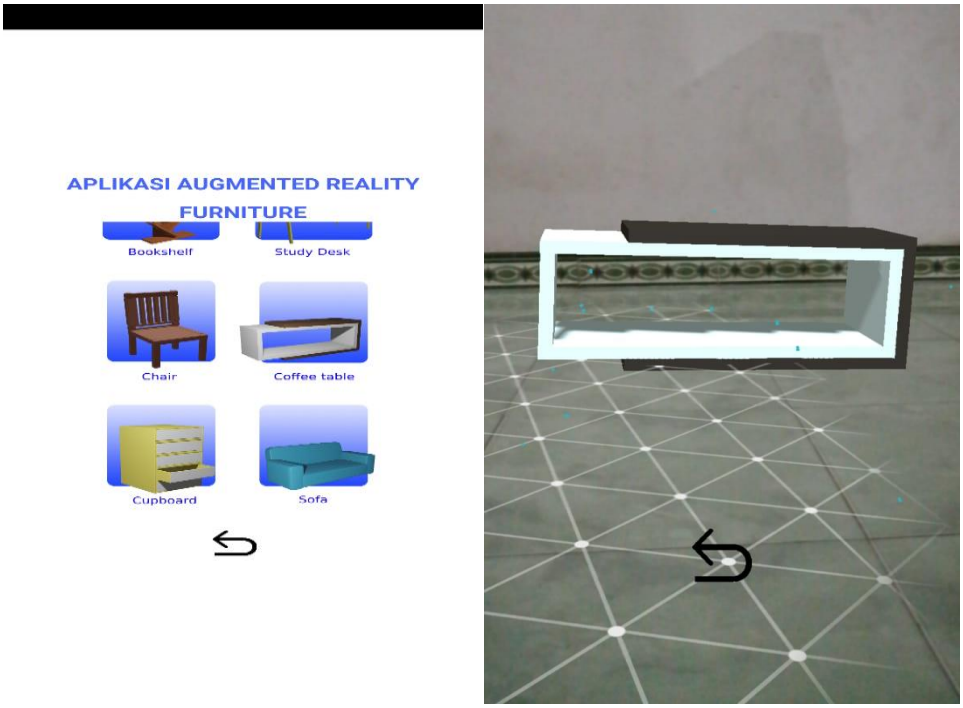

Fig. 9. Augmented Reality Page

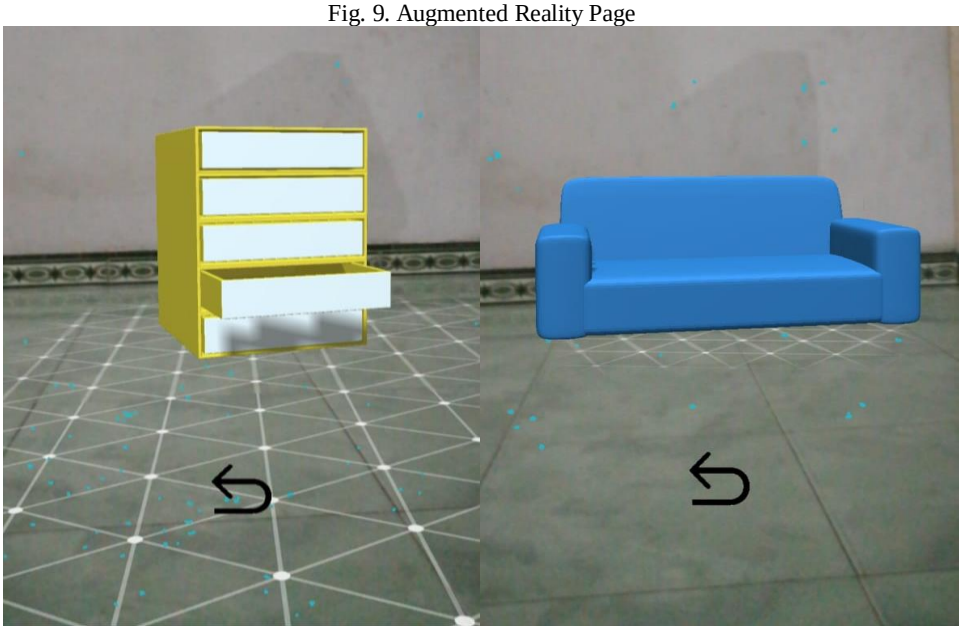

Fig. 10. Augmented Reality Display

In the image above you can see the results of the 3D interior objects that have been created previously, in the form of Augmented Reality. When the camera is activated, it will automatically look for a marker to be able to see the object. For all object images, there is a back button that functions to return to the previous page so you can select the object you want to display. The last menu in this application is the Chat facility as shown in Figure 11.

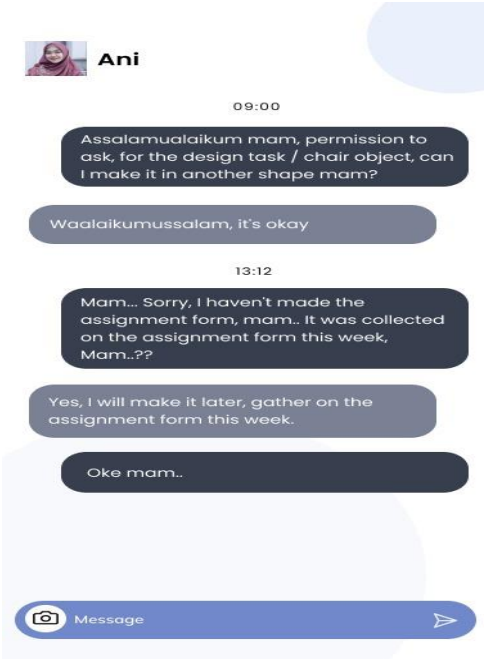

Fig. 11. Message page

The Message page functions for direct discussion chat between lecturers and students or students and other students regarding learning, so that learning can take place interactively.

5. Conclusion

Based on the results of research at the functional development stage of the digital learning application system for learning 3D graphic design based on Augmented Reality, it can be concluded as follows: The application of Augmented Reality to display 3D interior design objects that students have created can be displayed in the real world in real-time is something that interesting for them, so that the learning process becomes fun, they also indirectly have skills and abilities in mastering Augmented Reality technology. Using digital learning applications for learning can help students continue to practice creating design objects following video tutorials in the application. The DiGi.AR application is stated to be practical for use as a digital learning medium for 3D graphic design courses based on data processing of lecturer and student respondents with the average Aiken's V score from lecturers being 85.22% and small group test students 82.96% and group test students large is 83.04%. The limitations of this research are only limited to the application of digital learning applications in one 3D graphic design course, and it is only used at one university.

References

Aka, K. A. (2019). Integration Borg & Gall (1983) and Lee & Owen (2004) models as an alternative model of design-based research of interactive multimedia in elementary school. *Journal of Physics: Conference Series*, *1318*(1). https://doi.org/10.1088/1742-6596/1318/1/012022

Akbar, M. (2016). Digital technology shaping teaching practices in higher education. *Frontiers in ICT*, *3*(FEB), 1–5. https://doi.org/10.3389/fict.2016.00001

Antonides, G., & Hovestadt, L. (2021). Product attributes, evaluability, and consumer satisfaction. *Sustainability (Switzerland)*, *13*(22). https://doi.org/10.3390/su132212393

Asda, V. D., Asda, E. F., Aulia, F., Asdi, A., & Jamal, R. (2022). Validity and Practicality of Colloid E-Learning Content Based on Individual Rotation Guided Inquiry for Senior High School. *International Journal of High Information, Computerization, Engineering and Applied Science (Jhice)*, *2*(02), 46–53. https://doi.org/10.24036/jhice/vol2-iss02/57

Asrizal, Desnita, & Darvina, Y. (2021). Analysis of validity and practicality test of physics enrichment e-book based on CTL and enviromental factor. *Journal of Physics: Conference*

Series, *1876*(1). https://doi.org/10.1088/1742-6596/1876/1/012034

Astutik, S., & Prahani, B. K. (2018). The practicality and effectiveness of Collaborative Creativity Learning (CCL) model by using PhET simulation to increase students' scientific creativity. *International Journal of Instruction*, *11*(4), 409–424. https://doi.org/10.12973/iji.2018.11426a

Bahuguna, Y., Verma, A., & Raj, K. (2018). Smart learning based on augmented reality with android platform and its applicability. *Proceedings - 2018 3rd International Conference On Internet of Things: Smart Innovation and Usages, IoT-SIU 2018*, 1–5. https://doi.org/10.1109/IoT-SIU.2018.8519853

Bentri, A., & Hidayati, A. (2022). The Developing of Digital Pedagogical Curriculum of Primary Education Teachers in Indonesia. *Journal of Physics: Conference Series*, *2309*(1). https://doi.org/10.1088/1742-6596/2309/1/012097

Cai, S. (2016). Case studies of augmented reality applications for authentic learning. *Lecture Notes in Educational Technology*, *9789811059292*, 115–134. https://doi.org/10.1007/978-981-10-5930-8_8

Chen, H., Feng, K., Mo, C., Cheng, S., Guo, Z., & Huang, Y. (2011). Application of augmented reality in engineering graphics education. *ITME 2011 - Proceedings: 2011 IEEE International Symposium on IT in Medicine and Education*, *2*, 362–365. https://doi.org/10.1109/ITiME.2011.6132125

Diah, N., Elfis, E., & Titisari, P. (2021). *Development of Learning Media Based on Comic to Increase Students' Learning Outcomes at Junior High School*. https://doi.org/10.4108/eai.11-9-2019.2298645

Elfeky, A. I. M., & Elbyaly, M. Y. H. (2021). Developing skills of fashion design by augmented reality technology in higher education. *Interactive Learning Environments*, *29*(1), 17–32. https://doi.org/10.1080/10494820.2018.1558259

Enzai, N. I. M., Ahmad, N., Ghani, M. A. H. A., Rais, S. S., & Mohamed, S. (2020). Development of Augmented Reality (AR) for Innovative Teaching and Learning in Engineering Education. *Asian Journal of University Education*, *16*(4), 99–108. https://doi.org/10.24191/ajue.v16i4.11954

Falode, O. C., Dome, K., Chukwuemeka, E. J., & Falode, M. E. (2022). Development of an Interactive Mobile Application for Learning Undergraduate Educational Technology Concepts. *International Journal of Professional Development, Learners and Learning*, *4*(1), ep2204. https://doi.org/10.30935/ijpdll/12009

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*(May), 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Hamzah, M. L., Ambiyar, Rizal, F., Simatupang, W., Irfan, D., & Refdinal. (2021). Development of Augmented Reality Application for Learning Computer Network Device. *International Journal of Interactive Mobile Technologies*, *15*(12), 47–64. https://doi.org/10.3991/ijim.v15i12.21993

Huda, A. (2021). Augmented Reality Technology as a Complement on Graphic Design to Face Revolution Industry 4.0 Learning and Competence: The Development and Validity. *International Journal of Interactive Mobile Technologies*, *15*(5), 116–126. https://doi.org/10.3991/ijim.v15i05.20905

Hutchinson, S., Mirza, M. M., West, N., Karabiyik, U., Rogers, M. K., Mukherjee, T., Aggarwal, S., Chung, H., & Pettus-Davis, C. (2022). Investigating Wearable Fitness Applications: Data Privacy and Digital Forensics Analysis on Android. *Applied Sciences (Switzerland)*, *12*(19). https://doi.org/10.3390/app12199747

Kencana, M., Efi, A., Wakhinuddin, W., & Ambiyar, A. (2022). model of work-based learning in accordance with the concept of Kampus Merdeka in vocational education. *International Journal of Health Sciences*, *6*(July), 5563–5574. https://doi.org/10.53730/ijhs.v6ns6.10854

Kusumaningrum, A., Ayuningtyas, A., & Lopes, J. B. (2019). Utilization of Augmented Reality Technology in 3D Visualization of High School of Adisutjipto Technology Based on Android. *International Journal of Engineering Technology and Natural Sciences*, *1*(2), 40–44. https://doi.org/10.46923/ijets.v1i2.49

Liono, R. A., Amanda, N., Pratiwi, A., & Gunawan, A. A. S. (2021). A Systematic Literature Review: Learning with Visual by the Help of Augmented Reality Helps Students Learn Better. *Procedia Computer Science*, *179*, 144–152. https://doi.org/10.1016/j.procs.2020.12.019

Maulidya, R., Yeni, L. F., & Titin, T. (2022). Feasibility of Flash Flipbook Media of Fungi Classification Based on the Fungi Inventory in Mount Pemangkat. *Journal of Biology Learning*, *4*(1), 1. https://doi.org/10.32585/jbl.v4i1.1851

Mayefis, R. (2022). Mobile Learning Media for Computer and Based Network at Vocational High School. *International Journal of Natural Science and Engineering*, *6*(1), 21–29. https://doi.org/10.23887/ijnse.v6i1.48036

Muhardi, Anwar, S., Rukun, K., & Jasrial. (2017). Learning Model Development Using Moodle E-Learning Software By Implementing Borg And Gall Method. *Proceeding International Conference on Information Technology and Business*, *0*(0), 167–176. https://jurnal.darmajaya.ac.id/index.php/icitb/article/view/1017

Ningsih, S., & Adesti, A. (2020). *Android-Based Mobile Learning: Its Effect on Students' Learning Achievement*. *422*(Icope 2019), 100–103. https://doi.org/10.2991/assehr.k.200323.099

Poláková, P. (2022). Use of a mobile learning application in the process of foreign vocabulary learning. *Procedia Computer Science*, *207*(Kes), 64–70. https://doi.org/10.1016/j.procs.2022.09.038

Putri, I. K., Zaim, M., & Refnaldi, R. (2019). *Developing Instruments for Evaluating the Implementation of Authentic Assessment for Speaking Skill at Junior High School*. *276*(Icoelt 2018), 98–105. https://doi.org/10.2991/icoelt-18.2019.17

Raschka, S. (2018). *Model Evaluation, Model Selection, and Algorithm Selection in Machine Learning*. http://arxiv.org/abs/1811.12808

Rini, F., Mulyadi, R., Surya, J., & Louis, A. (2020). The Validity of Mobile Learning Management System (M-LMS) at University. *Journal of Computational and Theoretical Nanoscience*, *17*(6), 2836–2842. https://doi.org/10.1166/jctn.2020.8948

Shah, T. R., & Ali, H. M. (2019). Applications of hybrid nanofluids in solar energy, practical limitations and challenges: A critical review. *Solar Energy*, *183*(February), 173–203. https://doi.org/10.1016/j.solener.2019.03.012

Supriyanto, Joshua, Q., Abdullah, A. G., Tettehfio, E. O., & Ramdani, S. D. (2023). Application of Augmented Reality (AR) in vocational education: A systematic literature review. *Jurnal Pendidikan Vokasi*, *13*(2), 196–204. https://doi.org/10.21831/jpv.v13i2.54280

Syawaludin, A., Gunarhadi, & Rintayati, P. (2019). Development of augmented reality-based interactive multimedia to improve critical thinking skills in science learning. *International Journal of Instruction*, *12*(4), 331–344. https://doi.org/10.29333/iji.2019.12421a

Triadiarti, Y., Ane, L., Situmeang, C., & Mulasi, Y. P. (2021). *JPPI (Jurnal Penelitian Pendidikan Indonesia) Policy analysis of using smartphones as learning media at senior high schools*. *7*(4), 707–711. https://doi.org/10.29210/020211469

Ulfa, A. M., Sugiyarto, K. H., & Ikhsan, J. (2017). The effect of the use of android-based application in learning together to improve students' academic performance. *AIP Conference Proceedings*, *1847*(January 2021). https://doi.org/10.1063/1.4983910

Veletsianos, G., VanLeeuwen, C. A., Belikov, O., & Johnson, N. (2021). An Analysis of Digital Education in Canada in 2017-2019. *International Review of Research in Open and Distance Learning*, *22*(2), 102–117. https://doi.org/10.19173/irrodl.v22i2.5108