

Edugame Augmented Reality as Learning Media for Human Blood Circulation System

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Abstract

Modified learning media with the latest technology are needed in the learning process to increase student interest and motivation to learn. At present, AR (Augmented Reality) technology which is able to realize virtual 3D objects into the real world in real-time has been widely applied in various fields, one of which is education. This technology can be used to study the circulatory system which is one of the obstacles for students. The problem is the media used in learning on this material usually still uses conventional media. Meanwhile, students will better understand if there is a real visualization in front of them. It is good if you take advantage of this AR technology and educational games that are easily accessed from their gadgets because it is based on Android. So that they can provide visualization and more information, and attract the students' interest and motivation to learn. This game research was carried out using the Game Development Life Cycle (GDLC) method for the development stage and using the Black box for testing. As for application development using the multiplatform 3D Game Engine and 3D asset modeling engine. The test results obtained indicate that this augmented reality educational game can run well and can be an alternative learning media that is more varied, innovative, and easier to use.

Keywords : android, augmented reality, game education, human circulatory system, learning media.

I. INTRODUCTION

All efforts and research in the educational field is continuously done so as to create a new and more efficient learning process and attract the students' interest and motivation in learning. New innovations in this educational field are carried out by finding learning media that make use technology and learning models such as online learning, blended learning, etc. Nowadays, in learning something in school, printed media and teaching aids are still widely used by many schools. As a matter of fact, in the era of 1980s to 1990s, developed countries had begun to recognize the existence of multimedia technology that can empower the educational process by innovatively increasing interactions among teachers, students, and courseware in an innovative so that learning becomes more dynamic, easier to remember, and fun [1].

In addition to make use multimedia, many also use games as learning media. Even previous research states that educational games can be used for early childhood to give a new nuance in education to be more varied. It is due to some obstacles found in the form of lack of students' learning interest and lack of learning media facilities [2], [3]. Additionally, the game has a special attraction in attracting the users' attention that is enjoyable. Thus, edugame can be another alternative to overcome those obstacles [4].

Edugame can certainly be used by students at the middle level who they mostly have a gadget. This will greatly help increase the students' satisfaction who are eager to seek knowledge that is obstructed by the current educational model, especially for subjects that require real description. This means that it is not merely learning by visualizing in the students' imagination, such as natural science subject (IPA) especially Biology. Kolbert Pakpahan et al said that the circulatory system material is always difficult to learn [5].

Augmented Reality (AR) is the integration of 2D and 3D objects from digital elements into the real world in real-time. Pokemon Go game is one of the AR games that has become a trend in 2016. The game has a positive goal for adolescent to increase physical activity outside the home and to socialize [6]. Moreover, Saputro dan Saputra (2015) states that technology is commonly used in the fields of entertainment, advertising, health, military, and education. In education, many pieces of research has been carried out such as in Mathematics, History, Chemistry, Biology, and so on [8]–[10]. For Biology, some scholars have designed the learning application of human organs [11], [12]. There are also those who conduct research in this area and focus on the digestive organs and anatomy of the human heart and the circulatory system [7], [13]. This research aims to take advantage of AR as a learning media in learning the human circulatory system and integrating it with the concept of educational games. So far, the learning of blood circulatory system is still restricted to the use of teaching aids, practicums, blended learning, 3D visualization, animation, etc.[14]–[17]. Therefore, it can be the new alternative in the form of edugame *Augmented Reality* using *marker based tracing* method.

II. RESEARCH METHOD

The methodology used in this study was Game Development Life Cycle (GDLC). In practically developing a game, it is not

enough to adopt the SDLC (Software Development Life Cycle) method because it will encounter several challenges during its life cycle [18]. The method consists of 6 phases explained in Figure 1.

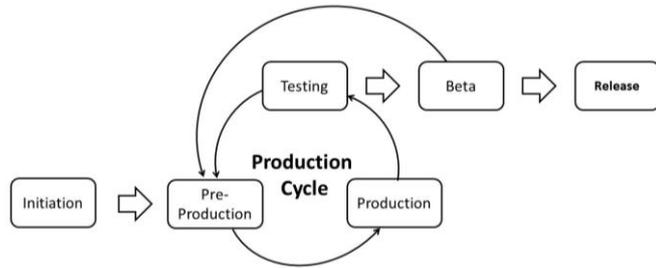


Figure 1. Flowchart 6 Phases GDLC

The research processes are:

II.I. Initiation

Edugame AR is used as a learning media for the human blood circulatory system that can be run on android devices and uses markerbased tracking methods. This game addresses middle level students. Based on previous research, the AR work scheme is shown in Figure 2.

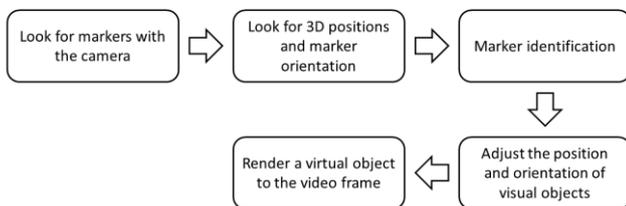


Figure 2. AR Work Scheme

When accessing the application, the camera will capture data from markers in the real world. Then the software will seek the position and shape of the marker to be identified. After that, there will be a calculation of the position and orientation of the camera onto the marker. When the calculation is complete, the model will be displayed on the screen to be seen in the real world [19].

The general description of Edugame AR application is that we can understand it through the use case diagram. Use case is one of the diagrams that shows the interaction between the user and the system [20]. The diagram is shown in the figure 3.

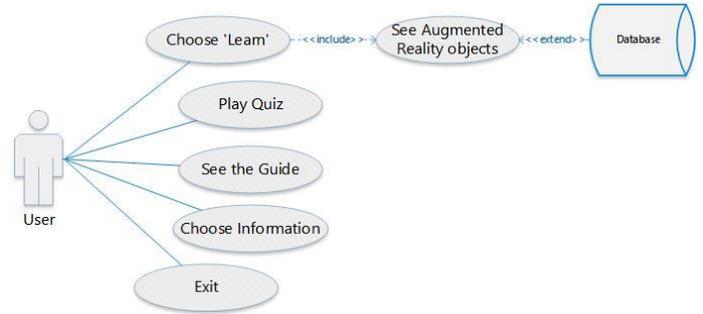


Figure 3. Use Case Application

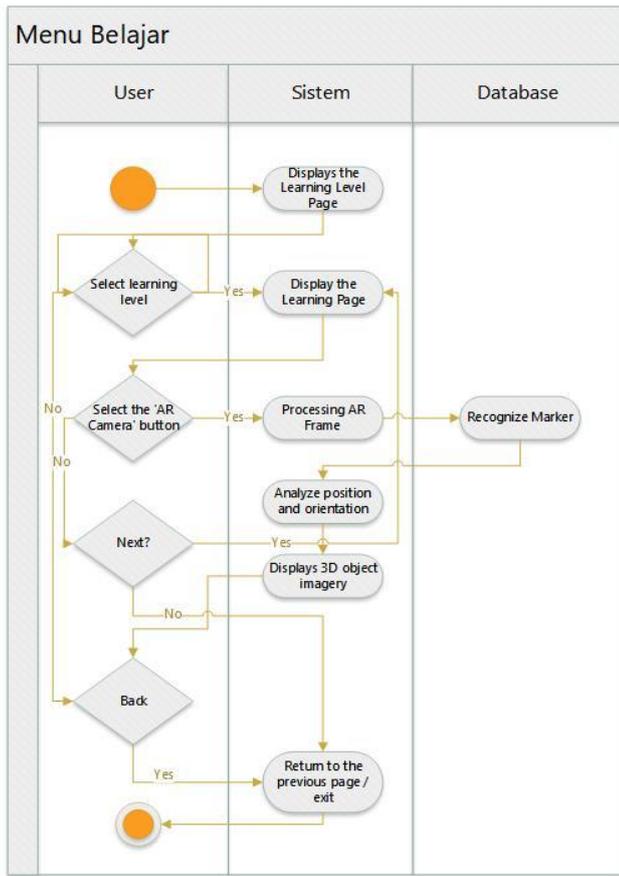
II.II. Pre-Production

The main part of this stage is the production of game designs and its revisions as well as the production of game prototypes. Game design starts with the making of Game Design Documentation (GDD), by which the summary is explained in Table 1. After GDD is produced, a prototype will be made to assess the game design and all ideas.

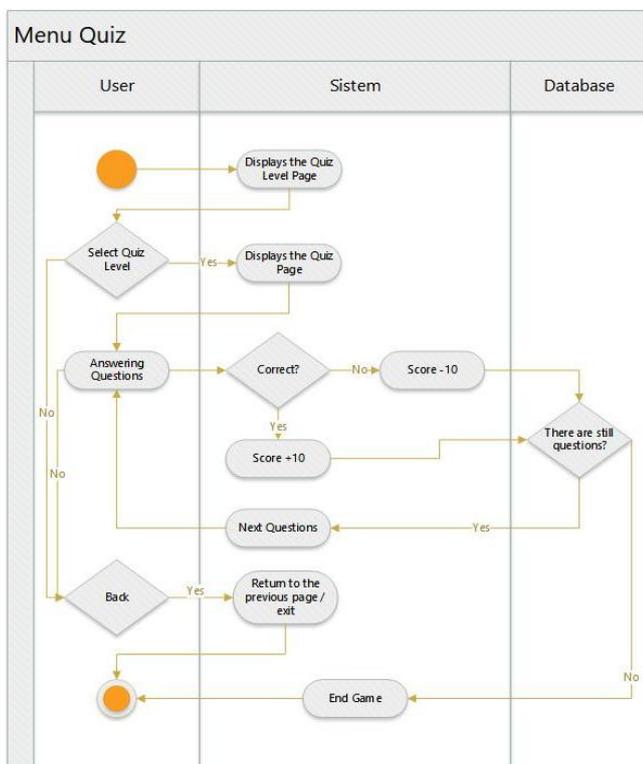
Table 1. Core of GDD

1	Game Concept	Learning blood circulation system easily
2	Target	Middle level students
3	Genre	Puzzle
4	Platform	Mobile game
5	Storyline	This application provides materials and quiz. The quiz is in the form of question along with the answer by the levels below: Level 1. Blood and Blood Vessels Level 2. Heart Level 3. Blood Circulation and Disease
6	Software Requirement	3D Game Engine, Modelling asset Engine, Vuforia Qualcomm, Android SDK, JDK
7	Hardware Requirement	Minimum. specification: <ul style="list-style-type: none"> Smartphone: Android with camera 5MP, RAM 1GB, OS min. KitKat. Laptop: processor Quad-Core 1.2 GHz and RAM 2GB

Furthermore, the diagram of main activities in the game is *Menu Belajar dan Quiz* (Learning Menu and Quiz) shown in Figure 4.



(a)



(b)

Figure 4. Activity Diagram (a) Learning Menu and (b) Quiz

The storyboard or sketch of images arranged in sequence in order to facilitate the flow delivery of this application is described as follows:

II.II.I. Main Menu

The page display design showing main menu will provide the application title and 5 buttons in the form of learning buttons, quizzes, guides, information, and exits. The wireframe design is shown in Figure 5.

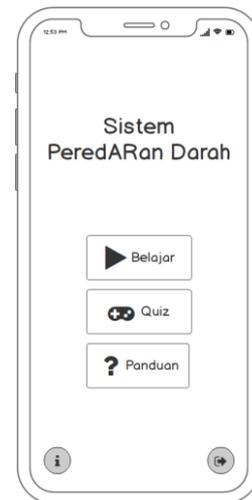
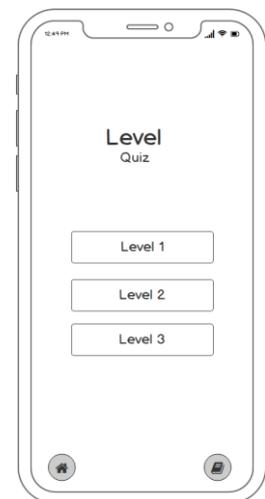


Figure 5. Design of Learning Menu Display

Next, the display design that is the main parts of this application such as learning and quiz is shown in Figures 6.a and 6.b. After the user selects a learning button or Quiz on the main page, it will immediately display the level menu page from the Learning Page or Quiz.



(a)



(b)

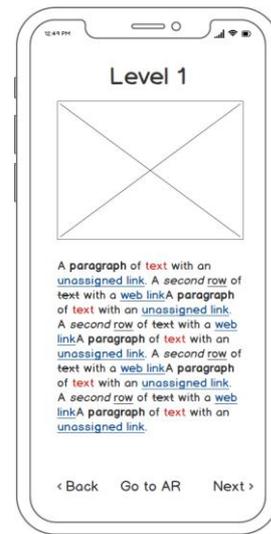
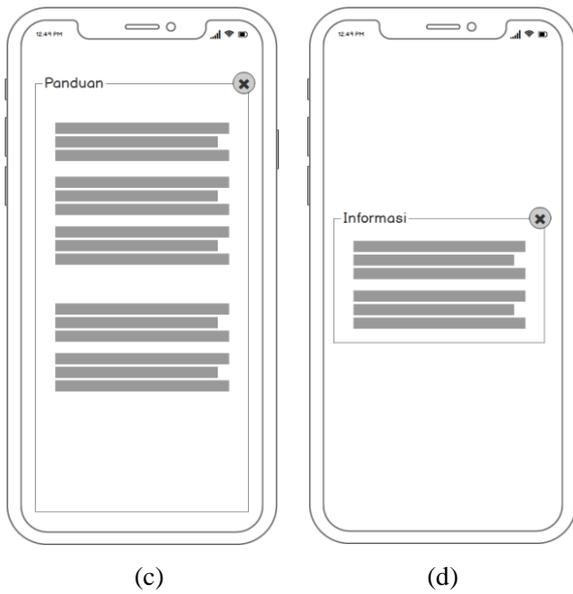


Figure 8. Display Design of Learning Menu



Figure 6. Wireframe as the Part of Home: (a) Learn, (b) Quiz, (c) Guide, (d) Information, dan (e) Exit.

Whereas, Figure 6.c and 6.d are in the form of a pop up containing the application usage guide and information about the developer. Figure 6.e is in the form of an exit display in the game which brings up a pop up to ensure users' certainty to exit the application.

II.II.II. Learning Menu Page

If the user presses the level button, the user will go to the learning page based on the selected level, for instance, level 1 learning displayed in Figure 8.

On this page, the user can learn the blood circulatory system material before taking the quiz. At the bottom, there is a 'back' button to return to the previous material, a 'Go to AR' button to open a page containing an AR frame, and the next button to go to the next material.

II.II.III. AR Camera Page

The display design of AR Camera is shown in Figure 9. The user must position the camera on the available marker to display the AR object. After AR appears, there is an (x) button to exit AR and return to the previous page.

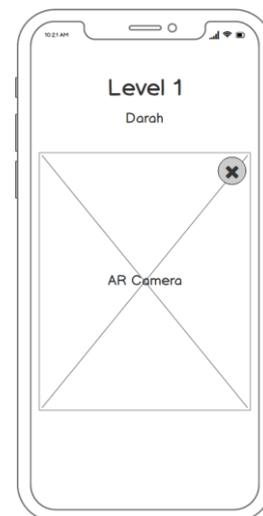


Figure 9. Display Design of AR

II.II.IV. Quiz Page

When the user presses the Quiz button on the main page, a Quiz level page will appear. After selecting a level, a Quiz with multiple choice questions and answers as shown in Figure 10.a will appear.

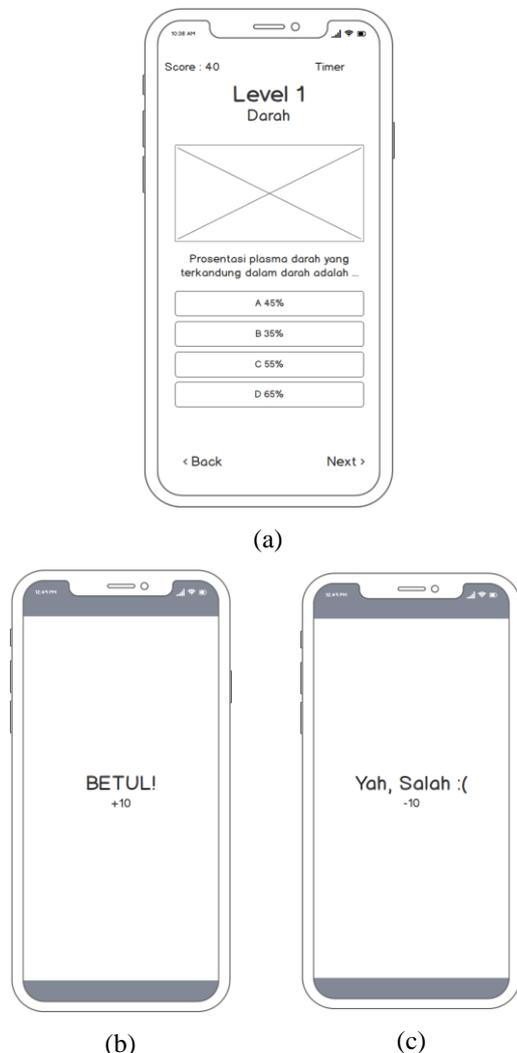


Figure 10. Display Design (a) Quiz Page, (b) Reward, and (c) Punishment

The reward of this game is in the form of additional 10 points if it correctly answered the question, while punishment is in the form of a 10-point score reduction. Each level has a greater difficulty level with challenges in the form of a timer since entering level 2. The display design for reward and punishment is explained in Figure 10.b. and 10.c to show the change in score that is achieved.

II.III. Production

This is the most important process in which all concepts, designs and plans contained in the GDD will be implemented. The process of assets modeling in the form of 3D objects from

organs in the circulatory system is carried out during this process. Besides, a good integration between asset production and source code is required so that the game can run well.

II.IV. Testing

The finding of bug reports, changing requests, and development decisions using black box testing will be recorded at this stage to be fixed. This is where the decision to enter the next stage or repeat the production process is taken.

II.V. Beta

The game in beta version that was made still needs improvement, so it needs retesting to determine the application's feasibility by detailing and perfecting it [21]. GDLC method allows repetition at this stage if changes to the feature or gameplay are needed.

II.VI. Release

When the game is ready to use, the process involving the division of documentation, knowledge, and planning for the game maintenance occurs.

III. RESULT AND DISCUSSION

The results of this research are in the form of an edugame application that studies the circulatory system that is more easily understood. The appearance of the application is as follows:

III.I. Home Page

On this page, there are three buttons located in the middle of the page as shown in Figure 11.a. Those three buttons are in the form of learning buttons that display material from the circulatory system, the quiz button to enter the quiz level page, a guide to give direction when you want to use AR. Additionally, there is also an info button that displays information about the application developer and an exit button.

When the user clicks on the learning button, a learning page will appear with a button in the form of learning levels, a Home button to return to the main page (Home), and a Quiz button to go directly to the quiz page. The Learning and Quiz pages have a similar layout, but the difference is the button in the lower left corner. The page display of Learning and Quiz level menu is illustrated in Figure 11.b and 11.c.

Detailed display of the guide, information and also the exit is shown in Figure 11.d, 11.e, and 11.f. The (x) button on the guide display functions to exit and return to the Home page. Meanwhile, on the information page, the user can click on the pop up to return. Furthermore, if the user clicks the exit button, a pop up option will appear to exit or cancel the application.

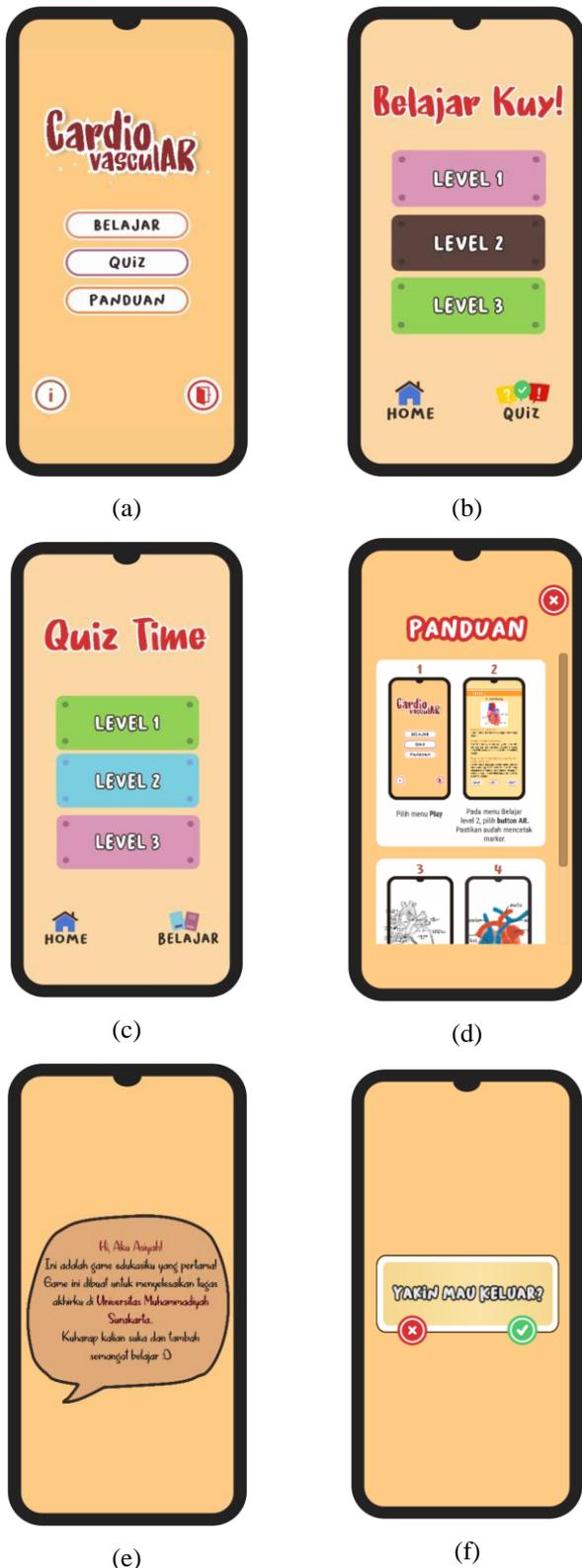


Figure 11. Display (a) Main Menu and its Parts : Level Menu (b) Learning and (c) Quiz, (d) Guide, (e) Information, and (f) Exit

III.II. Learning Page

The page menu of learning level in Figure 11.b consists of three levels that have been designed to study the circulatory system material based on sub-material. Because the circulatory system material is divided into three sub-materials, namely blood at level 1, heart and blood vessels at level 2, and disorders or abnormalities in the circulatory system and efforts to prevent and treat it at level 3. The material has been adjusted with the indicators contained in the Lesson Plan (RPP).

Each level has a back button to return to the previous slide, next to go to the next material, and a level banner that will take the user to the page menu of learning level . Figure 12 is a display of the Learning Pages for each level:

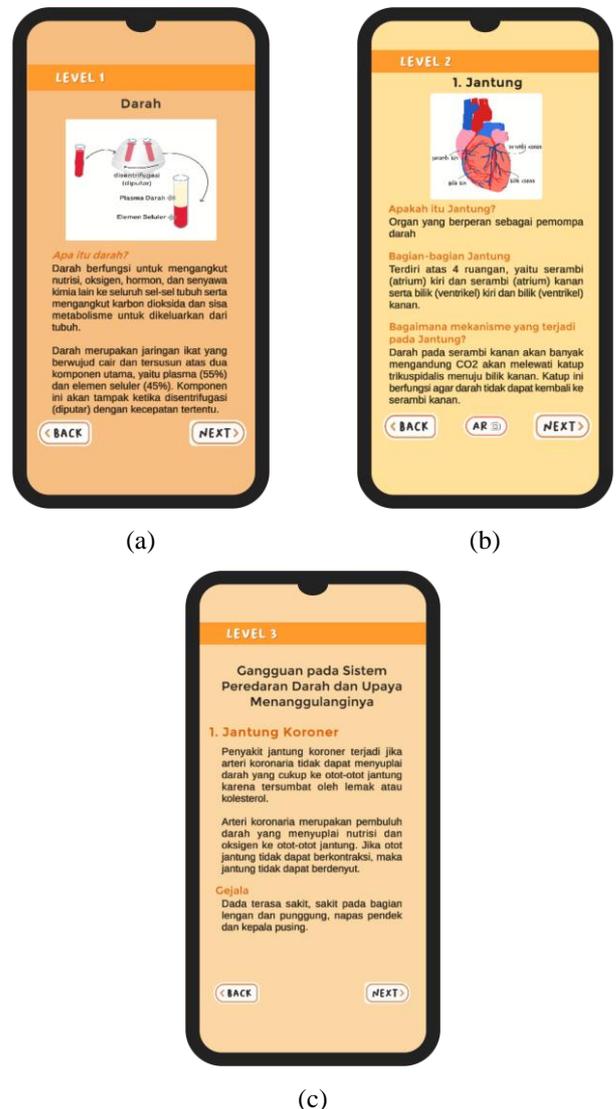
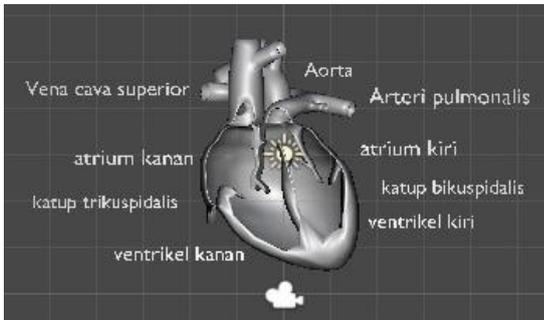


Figure 12. Part of Learning level menu . (a) Level 1, (b) 2, and (c) 3.

III.III. AR Page

When in level 2, there is an AR camera button that displays heart AR. Because this application is designed to teach the circulatory system including the heart organ that plays a major

role, the 3D model is designed based on information on the components of the heart [13]. 3D Model is shown in figure 13.a.



(a)



(b)

Figure 13. Display of (a) heart 3D model and (b) AR object after *building app*

To be able to display AR objects, the user must try to position the camera facing the marker. The following screenshots are obtained as shown in Figure 13.b. In the AR object display, there is a slight change in the heart detailing of the original file after exported to the apk format. This is due to differences in the engine renderer from the 3D modeling asset application and the 3D game engine used. In this case, researchers use Blender 2.8 application to model 3D objects and Unity 2019.3.12f as a game engine.

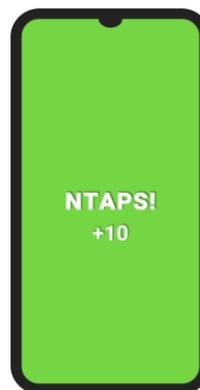
III.IV. Quiz Page

This page shows a multiple choice quiz of material contained in this application. The goal is to hone the understanding and memory of the material that has been presented. The available levels are also adjusted to the sub-material on the Learning level menu. Each level consists of 15 randomized questions. The appearance of the quiz page is shown in Figure 14.



Figure 14. Quiz Page Display without Timer

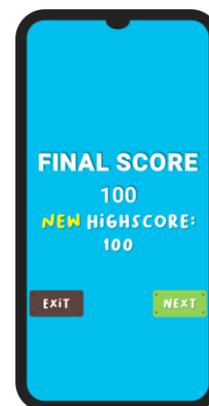
If the problem is answered correctly or incorrectly, and has completed a level is shown in Figure 17.a and 17.b. The display appears for a few seconds then the next question display continues. Furthermore, in the Final Score Display (figure 17.c) there is a button to exit the game, to the Quiz level menu page and also next to continue to a higher level



(a)



(b)



(c)

Figure 15. Reward Display. (a) correct, (b) incorrect, and (c) final score.

III.V. Blackbox Testing

If the problem is answered correctly or incorrectly, and has completed a level shown in Figure 17.a and 17.b. The display appears for a few seconds then the next question display continues. Also in the Final Score display (figure 17.c) there is a

button to exit the game to the Quiz level menu page and also next to continue to a higher level, Redmi note 5. The test results are shown in table 2. The Blackbox test in table 2 shows that the Augmented Reality edugame application to study the circulatory system gets valid results. So it can run well on Android devices and can be used.

Table 2. Result of Blackbox *testing*

No	Page	Testing Scenario	Output	Result	
1	Home	Learning Button	Clicking learning button	Entering the learning level page	valid
		Quiz Button	Clicking quiz button	Entering the quiz level page	valid
		Guide Button	Clicking guide button	Entering the guide page	valid
		Information Button	Clicking information button	Displaying pop-up info	valid
		Exit Button	Clicking exit button	Exiting the application	valid
2	Learning Level Menu	Level 1 Button	Clicking level 1 button	Moving to learning level page level 1, displaying blood sub-materials	valid
		Level 2 Button	Clicking level 2 button	Moving to learning level page level 2, displaying sub-materials of heart and blood circulation.	valid
		Level 3 Button	Clicking level 3 button	Move to learning level page level 3, displaying the section on disorders of the circulatory system and how to overcome them	valid
		Home Button	Clicking home button	Going back to Home Page	valid
		Quiz Button	Clicking Clicking quiz button	Moving to Quiz Page	valid
3	Quiz Level Menu	Level 1 Button	Clicking level 1 button	Moving to Quiz Page Level 1, answering multiple choice questions	valid
		Level 2 Button	Clicking level 2 button	Moving to Quiz Page Level 2, answering multiple choice questions	valid
		Level 3 Button	Clicking level 3 button	Moving to Quiz Page Level 3, answering multiple choice questions	valid
		Home Button	Clicking Home button	Moving to homepage	valid
		Learning Button	Clicking Learning button	Moving to Learning Level Page	valid
4	Learning level 1, 2, and 3	Next Button	Clicking Next button	Displaying next page	valid
		Back Button	Clicking Back button	Displaying previous page	valid
		Banner level	Clicking Banner Level	Moving to Learning Level menu page	valid
5	AR	Button (X)	Clicking (x)button	Exiting AR application to previous pages	valid
6	Quiz Level 1	Multiple Choice Button	Clicking one of the options	Whether correct or incorrect, displaying final score	valid
		Retry Button	Clicking Retry button	Replaying the game	valid
		Next Button	Clicking Next button	Moving to next level	valid

IV. CONCLUSION

This Augmented Reality-based edugame has gone through a series of tests with a Black box to determine its feasibility and functionality. The results show that this application can run well on Android smartphone devices. As a result, this application can be used by middle level students as one of the fun alternatives in learning the circulatory system. There are minor detailing changes to 3D AR objects, those are due to differences in rendering engine in Blender and Unity. The solution is based on blendermarket.com page, if you want to have the same details then you can use the paid B2U add-on [22].

There are suggestions that can be carried out by further research. It would be better if this application could be developed so that it has more Quiz levels. This can be useful for honing students' deeper understanding. In addition, the appearance of the application and other features can also be improved to be more interactive and innovative.

REFERENCES

- [1] Almara'beh H, Amer EF, Sulieman A. The effectiveness of multimedia learning tools in education. *International Journal of Advanced Research in Computer Science and Software Engineering*. 2015 Dec.
- [2] Fajar N. Proses pembelajaran biologi pada materi sistem peredaran darah manusia di kelas VIII SMP Negeri 3 Rambatan. *Ta'dib*. 2016 Jul 15;19(2):103-14.
- [3] Fithri DL, Setiawan DA. Analisa Dan Perancangan Game Edukasi Sebagai Motivasi Belajar Untuk Anak Usia Dini. *Simetris: Jurnal Teknik Mesin, Elektro dan Ilmu Komputer*. 2017 Apr 1;8(1):225-30.
- [4] Al Irsyadi FY, Puspitassari D, Kurniawan YI. ABAS (Ayo Belajar Sholat): Game Edukasi Pembelajaran Sholat Untuk Anak Tuna Rungu Wicara. *Jurnal Manajemen Informatika (JAMIKA)*. 2019 May 13;9(1):17-28.
- [5] Pakpahan K, Situmorang J. PENINGKATAN HASIL BELAJAR BIOLOGI SISWA DENGAN MENGGUNAKAN METODE BERMAIN PERAN PADA MATERI SISTEM PEREDARAN DARAH MANUSIA. *Jurnal Teknologi Pendidikan (JTP)*.;11(2):154-66.
- [6] Wallace HS. Augmented reality: Exploring its potential for Extension. *Journal of Extension*. 2018 Sep 1;56(5).
- [7] Saputro RE, Saputra DI. Pengembangan Media Pembelajaran Mengenal Organ Pencernaan Manusia Menggunakan Teknologi Augmented Reality. *Jurnal Buana Informatika*. 2015 May 1;6(2).
- [8] Irwansyah FS, Yusuf YM, Farida I, Ramdhani MA. Augmented reality (AR) technology on the android operating system in chemistry learning. *InIOP conference series: Materials science and engineering* 2018 Aug (Vol. 288, No. 1, p. 012068).
- [9] Challenor J, Ma M. A Review of Augmented Reality Applications for History Education and Heritage Visualisation. *Multimodal Technologies and Interaction*. 2019 Jun;3(2):39.
- [10] Buchori A, Setyosari P, Dasna IW, Ulfa S. Mobile Augmented Reality Media Design with Waterfall Model for Learning Geometry in College. *International Journal of Applied Engineering Research*. 2017;12(13):3773-80.
- [11] Santoso A, Noviandi E. Rancang Bangun Aplikasi Pembelajaran Organ Tubuh Berbasis Augmented Reality. *Jur. Tek. Inform. STMIK GI MDP*. 2013:1-9. (unpublished)
- [12] Sudarmilah E, Wibowo PA. Aplikasi Augmented Reality Game Edukasi untuk Pengenalan Organ Tubuh Manusia. *Khazanah Informatika: Jurnal Ilmu Komputer dan Informatika*. 2016 Jun 30;2(1):20-5.
- [13] Nuanmeesri S, Kadmateekarun P, Poomhiran L. Augmented Reality to Teach Human Heart Anatomy and Blood Flow. *Turkish Online Journal of Educational Technology-TOJET*. 2019 Jan;18(1):15-24.
- [14] Astiti IA, Sasmita GM, Sukarsa M. Penerapan Augmented Reality Video Dinamis dalam Pembelajaran Peredaran Darah Berbasis Android. *Jurnal Ilmiah Merpati (Menara Penelitian Akademika Teknologi Informasi)*. 2018:174-84.
- [15] Daulay UA. PENGARUH BLENDED LEARNING BERBASIS EDMODO DAN MOTIVASI BELAJAR TERHADAP HASIL BELAJAR IPA BIOLOGI DAN RETENSI SISWA PADA SISTEM PEREDARAN DARAH MANUSIA DI KELAS VIII SMP N 5 MEDAN (Doctoral dissertation, UNIMED).
- [16] Pratiwi B, Herlawati H. Animasi Interaktif Pengenalan Pembelajaran Sistem Peredaran Darah Pada SD Widya Bhakti Bekasi. *Bina Insani ICT Journal*. 2015 Mar 1;2(1):15-32.
- [17] Arini YD, Dayani S. Visualisasi 3 dimensi sistem peredaran darah manusia menggunakan teknik low poly dan particle system (Study Kasus: SDN Bintaro 01 Pagi). *JURNAL TEKNIK INFORMATIKA*. 2013 Oct 2;6(2).
- [18] Ramadan R, Widayani Y. Game development life cycle guidelines. In *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)* 2013 Sep 28 (pp. 95-100). IEEE.
- [19] Aditama PW, Adnyana IN, Ariningsih KA. AUGMENTED REALITY DALAM MULTIMEDIA PEMBELAJARAN. In *SENADA (Seminar Nasional Desain dan Arsitektur)* 2019 Feb 21 (Vol. 2, pp. 176-182).
- [20] Sudarmilah E, Supriyono H, Fadlilah U, Al Irsyadi FY, Fatmawati A. Prototyping AR EduGame for children:

- learning Indonesian culture. InMATEC Web of Conferences 2018 (Vol. 197, p. 03012). EDP Sciences.
- [21] Krisdiawan RA. Implementasi Model Pengembangan Sistem GDLC dan Algoritma Linear Congruential Generator pada Game Puzzle. Nuansa Informatika. 2018 Mar 10;12(2).
- [22] Cogumelo Softworks. B2u - Blender To Unity Prefab And Scene Exporter. [Online]. Available: <https://blendermarket.com/products/b2u>. [Accessed: 08-Jun-2020].