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Developing AR Learning and Its Effect on Independent Learning Compared to Traditional Learning

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Abstract **– Advances in educational technology have become the attention of researchers in the educational process. Today's students have left the old way of learning by switching to digital learning. Therefore, this study aims to develop Android Augmented Reality (AR) learning media and its effect on independent learning outcomes compared to traditional classroom learning. The research method combines R&D, experiment, and survey methods. The Alpha test showed the learning media application of AR functions according to the expected scenario. Meanwhile, the Beta test showed most students strongly agree that: AR learning media is easy to use; the content in the AR learning media is exciting and easy to understand. The subject matter in the AR learning media application is easy to understand, and AR learning media helps and facilitates students in learning the basics of car engine systems. At the same time, the Beta testing on a teacher showed AR educational media for the lubrication and car engine cooling systems is beneficial and suitable for classroom learning media. Furthermore, the t-test comparison test shows that students' AR independent learning outcomes are better than traditional learning AR subjects by teachers in the classroom.**

Keywords **– AR, independent learning, traditional learning, educational technology, learning media.**

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1. Introduction

The use of digital technology is rampant [1]. As a result, humans in this digital era are dependent on and closely related to technology. Technology has influenced human life and is no exception in the educational process. Technology has become a part of education and positively influences learning and teaching [2][3]. Besides that, technological developments have changed many areas of life by manifesting in different directions, including optimizing teaching and learning [4]. Technological advances are the concern of researchers to realize a technology-based education process [5][6][7][8]. Students today leave the old way of learning in the educational field by turning to computers and internet digital educational media [9][5]. Therefore along with the rapid development of educational technology, recommendations for the use of digital media in education have become a significant area of research today [9]. Educational media for learning must be available in the teaching process as a solution to solve the complexities of professional academic situations [10], and digital educational media can solve them [11][12]. Moreover, advances in educational technology enable digital-based learning processes [7]. For this reason, this research builds digital educational/learning media: AR, while the purpose of this study is to develop Android AR learning media and its effect on independent learning outcomes compared to traditional face-to-face learning in classrooms.

Digital learning has disrupted traditional learning activities [13][14]; where the success of students in digital learning essentially depends on self-regulation [13] and students' independent learning abilities based on subjects [15]. In essence, independent learning is important to research [16]. In independent learning, the teacher's role and responsibilities in the teaching process shift to students who learn independently, including learning how to learn independently [17]. However, despite the current importance of independent learning according to R.

Butson, S. John, and A. Suazo (2020) [18], but anyway the research question is how the success of student independent learning on the learning subject. This research will uncover it in AR learning media.

Some consider Independent learning as a substitute for face-to-face teaching, which is not so good [19] and several studies [18] [20] have confirmed some students do not have independent learning skills. In essence, there is a significant difference in the success of students' independent learning [21]. But on the other hand, schools still rely on student learning independence as students study most of the time [18]. Moreover, according to Barbosa et al. [22], almost two-thirds of the educational curriculum is divided into independent student learning outside the classroom. This is another reason for the need to conduct independent learning research to find out how well the learning outcomes of independent learning using AR learning media technology are compared to traditional learning in the classroom as this study was conducted.

AR is an application concept that combines the digital world with the physical world [23] without changing the shape of the physical object. Today, the use of digital AR technology is an important research topic in various fields [24]. AR improves cognitive thinking processes or reduces the cognitive load in understanding the lesson's content [25]. AR is virtual information technology for the existing environment to enhance the human senses [26]. AR offers benefits in the work environment, simulations of the natural world, and learning for students who no longer depend on expert performance [27]. AR is a multimedia transformation medium to the real world for use in web-based environments [25]. AR is a piece of digital technology. Recently, AR have become an essential research topic [28].

Although recently, there is little research on the effects and implications of AR applications in education science [29], AR research has increased sharply among various research institutions and universities [23]. AR technology combines the physical and digital worlds [30]. AR brings virtual information directly representing the real-world environment [31] in text, three-dimensional images, videos, and other forms [23] on mobile devices [30]. Moreover, the AR system enhances the capability of adopting information beyond the reach of human perception of the natural world [23][31]. In other words, the information presented by the AR system increases human perception to more easily understand the information contained therein. AR is the embodiment of a three-dimensional world using computer technology [32][33].

Along with the growing popularity of AR, efforts have been underway to develop AR-based learning [34]. AR is leading to a change in how education improves the quality of education as a whole [35]. AR technology dramatically impacts the present and future of future education [35]. AR instruments provide iterative learning that is independent of location and time and attainment of psychomotor skills [36][37][38]. The advantages of learning with AR are increasing learning achievement [39], increasing positive attitudes [40][41], and reducing cognitive load as a learning medium [42]. Moreover, AR is known as a technological advancement that bridges the gap between reality and the virtual world [43][44]. AR has become a platform that allows learners to observe phenomena that may not have been experienced in real life and are able to adjust to the level of understanding of each student [45].

Although relatively many previous studies related to AR, including research by Ana Javornik (2016), Chai-Fen Tsai et al. (2018), Mustafa Sirakaya and Didem Alsancak Sirakaya (2018), Anand Nayyar et al. (2018), Pietro Cipresso (2018), Shiqian Ke et al. (2019), N. Koteleva et al. (2020), David Parsons, Kathryn MacCallum (2021), Vasarainen, M et al. (2021), Caroline Kairu (2021), Elmira Daulethanovna Bazhenova et al. (2022), and Malek Jdaitawi et al. (2022), but none of the research objectives are the same and the methods used are the same as this study. In addition, no previous research has conducted research by comparing the results of independent learning with AR media developed on a mobile basis with traditional learning outcomes in AR subjects. Thus the results of this study provide important implications not only for the novelty of research results but also for the benefit of scientific advancement and the interests of the teaching and learning community.

The writing organization of the rest of the writing is as follows: the second subsection describes Related Works. The third subsection explores Research Methodology. The following sub-section discusses the research results and ends with a sub-section that concludes the research findings, novelties, and suggestions for further research.

2. Related Works

This subsection describes some of the most recent previous related works compared to this manuscript article. Ana Javornik (2016) reviewed AR's media characteristics and commercial applications [46]. This previous article is only a review article in prior works, which is different from the article in this

study which is an R & D work. The difference lies in the methods, objectives, and objects studied between previous studies and the articles in this study. Meanwhile Chai-Fen Tsai et al. (2018) compared VR and AR environments in triggering anxiety. Previous research focused on measuring participants' anxiety levels in VR and AR environments [47]. In contrast to the research in this article, it focuses on developing learning media for students about the process of lubricating and cooling car engines. Another difference is that previous related studies did not establish learning media and did not build mobile applications as in the article in this study.

Mustafa Sirakaya and Didem Alsancak Sirakaya (2018) identify research trends in AR education that show the use of AR in education tends to increase steadily [48]. This previous research differs from the research in this article in the research methods and research objectives and research results. Anand Nayyar et al. (2018) highlighted the application of AR and VR technologies to tourism and hospitality [49]. The differences between the research of this article and previous research are in the objective and method. Besides, in earlier research, the research object was not on learning media, as in this study's article. Pietro Cipresso et al. (2018) explored the significant effect and application of AR and VR technologies [50]. The difference between this article and the previous research is in the objectives, methods, and objects of research. For example, the previous research is literature review research, while the research in this article is R&D.

Shiqian Ke et al. (2019) compare the interactions that occur between VR, AR, and Mixed Reality (MR) and develop an enhanced interaction framework [51]. This previous research is not related to developing learning media and does not build mobile applications as researched in this article. The difference between the previous research and this article research is in the research object and the study purpose. Yunqiang Chen et al. (2019) reviewed the development of augmented reality and introduced augmented reality technology in several fields [23]. The difference between this previous research and the research in this article is in the objective, research method and object studied. In contrast, N. Koteleva et al. (2020) examined the efficiency of using AR for oil pump maintenance [52]. Previous research used AR technology to monitor through images maintained pump parameters and status. While the study in this article uses AR technology as a learning medium for students about the process of lubricating and cooling car engines. So the difference lies in the research objectives and the object studied between the previous study and this article research.

David Parsons, Kathryn MacCallum (2021) reviewed several previous works to identify the most effective AR capabilities [27]. This previous research is a literature review research different from the research in this article is R & D research. Besides that, the difference also lies in the object under study and the research objective. Vasarainen, M et al. (2021) reviewed the literature on changes in work organization due to Extended Reality: VR, AR, and mixed reality [53]. This previous research is different from the research in this article regarding the method, objective, and research object. Furthermore, this previous research is not research related to learning media, not R & D research, and does not build mobile applications as research in this article.

Caroline Kairu (2021) reviewed the cognitive impact and challenges of using AR in higher education [25]. This previous research is the same as the research in this article which focuses on discussing AR as a learning medium. However, the objectives, methods, and objects studied differ between the two. The research method in previous research is a literature review. In contrast, the research method in this article is R&D. The purpose and object of research of earlier studies are related to the effect of AR on cognitive thinking processes, while this article deals with learning media for learning lubrication and cooling systems for car engines. In addition, previous research did not build AR applications, while the research in this article builds AR applications. Elmira Daulet-novna Bazhenova et al. (2022) recapitulated empirical evidence on the effectiveness of VR-based learning for student learning performance [32]. Previous research is different from the research in this article. Previous research focused on VR environments, while the research in this article focuses on AR environments other than VR for student learning media. In principle, previous research differs in research methods, objectives, and objects compared to this article's research. For example, the previous research is review research, while the research in this article is R&D research. Malek Jdaitawi et al. (2022) did a usage review AR technology in education [24]. This previous study presents a literature review on education while the research in this article is to develop the use of AR technology for education. So the difference between this previous research and this research lies in the objectives and research methods.

Table 1 compares some of the most recent previous related work with this article research. Based on the elaboration of the latest related works, it shows that the research in this article has a novelty that has never been done by other researchers before. The novelty lies not only in building Android-based AR mobile learning media for car engine cooling and lubrication systems but also in conducting trials (experiments) comparing the learning outcomes of independent learning and traditional learning from the built AR learning. In essence, none of the previous related studies are the same as this research in the research methods used and research objectives.

Table 1. Comparison between some of the previous related works with this article

Research by	Type of Research	Learning trial		Research on Learning Media	Build Mobile Apps	Research Object
		Independent Learning	Traditional learning			
Ana Javornik (2016) [46]	Review	No	No	No	No	Reviewing the media characteristics and commercial applications of AR
Chai-Fen Tsai et al. (2018) [47]	Experiment	No	No	No	No	Comparing VR and AR environments in triggering participants' anxiety and triggering participants' physiological reactions
Mustafa Sirakaya and Didem Alsancak Sirakaya (2018) [48]	Review	No	No	No	No	Identify research trends in AR education.
Anand Nayyar et al. (2018) [49]	Review	No	No	No	No	Reviewing the history and use of VR/AR for tourism and hospitality
Shiqian Ke et al. (2019) [51]	Experiment	No	No	No	No	Comparing the interactions between VR, AR, and MR and refining the framework of the interactions that occur
Pietro Cipresso (2018) [50]	Review	No	No	No	No	Exploring the effect and application of AR and VR technologies
Yunqiang Chen et al. (2019) [23]	Review	No	No	No	No	Reviewing the development of augmented reality and the application of augmented reality technology in several fields
N. Koteleva et al. (2020) [52]	Experiment	No	No	No	Yes	Examining the efficiency of using AR for oil pump maintenance
David Parsons, Kathryn MacCallum (2021) [27]	Review	No	No	No	No	Review previous work to identify most effective AR capabilities
Vasarainen, M et al. (2021) [53]	Review	No	No	No	No	A review of the literature related to the effect of VR, AR, and their combination on changes in work organizations
Caroline Kairu (2021) [25]	Review	No	No	No	No	Reviewing the cognitive impact and challenges of using AR in higher education
Elmira Daulethanovna Bazhenova et al. (2022) [32]	Review	No	No	No	No	Recapitulating empirical evidence on the effectiveness R-based learning for student learning performance
Malek Jdaitawi et al. (2022) [24]	Review	No	No	Yes	No	Conduct a literature review of the use of AR in science Education
This (our) research	R&D, Survey, and Experiment	Yes	Yes	Yes	Yes	Developing AR technology-based digital learning media for car engine lubrication and cooling system education for students

3. Research Methodology

This research method combines R&D, survey, interview, and experiment methods (as shown in Figure 1). R&D is the activity involved in creating an innovative new product or service and is generally the first stage in the development process [54]. The R&D product built is AR learning media for car engine cooling and lubrication systems. The AR learning media built is a three-dimensional augmented reality (AR) learning media based on Android. This study uses a survey to collect quantitative ordinal data (quantitative research). The sample of the survey data is 30 students of natural science level 3 of senior high school. The survey instrument in this study used a Likert measurement scale with a measurement scale consisting of 4 answer choices: strongly agree, agree, disagree and strongly disagree. The survey was conducted to collect students' perceptions of AR products for car engine cooling and lubrication systems as learning media. In short, the survey aims to measure the effectiveness of the product being developed. Meanwhile the interview was conducted with school teacher to find out the teacher's perceptions about the benefits of AR cooling and lubricating car engine products in learning. The developed AR product was tested on students' independent learning. This means that one class consisting of 30 students is treated to independent learning of the developed AR product (experimental class). Then the results were compared with the face-to-face learning class of car engine cooling and lubrication systems which also consisted of 30 students (traditional class or face-to-face classroom class). Both the experimental class and the traditional class consisted of students at the same level who had never learned about car engine cooling and lubrication systems. The learning outcomes of both the experimental class and the traditional class were compared with a comparative test of two independent variable t-tests to find out which class was more successful in learning. Figure 2 shows the sequence of the implementation process of the research method in this study.

The process of developing AR learning media uses machine learning model-development lifecycle (MDLC) for car engine lubrication and cooling systems in this research. The MDLC consists of process stages: concept, design, material collection, assembly, testing, and distribution (see Figure 2) [55]. MDLC is useful in developing multimedia-based models [56][57]. MDLC offers relatively simple steps for developing multimedia models for learning media. In this study, the Method sub-section describes the

stages of the MDLC process: concept, design, and collecting materials, while the Results and Discussion sub-section elaborates on the stages of the MDLC process: assembly, testing, and distribution.

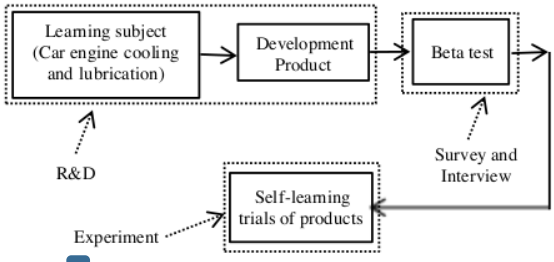

Figure 1. The research methods in this study

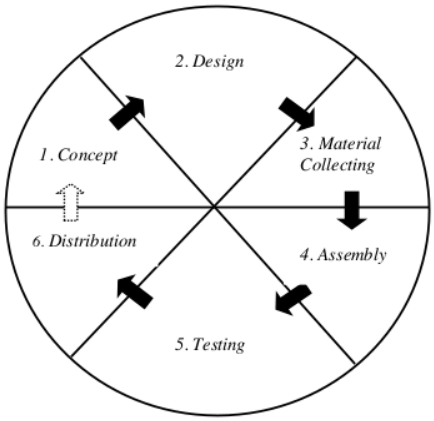

Figure 2. The step of the MDLC for AR learning media development

4. Result and Discussion

4.1. Concept

The conceptualization stage is setting goals, subjects, and product concepts. The subject of this research is learning about car engine lubrication and cooling systems for high school students. The aim of the study was to develop AR learning media products from car engine lubrication and cooling systems and then test the resulting product on the results of student self-learning. The concept of the learning media is for students and teachers to access mobile learning content on the lubrication system and car engine cooling system. The idea concept of learning media content is built based on AR technology. In short, the concept stage is the stage of determining the goals of developing the application and who its users are. The application developed is a teaching medium for teachers and learning media for students on basic learning materials of car engine systems based on AR technology. Table 2 shows the AR application development concept for essential learning media for car engine lubrication and cooling systems in car engine subjects.

Table 2. Learning Media Concept Of Car Engine Lubrication And Cooling Systems

Learning media concept	Description
Goal	Development of AR learning media for car engine lubrication and cooling systems
Technology	AR
Platform	Android 4.1 'Jelly Bean
User	Students and teachers
Interactive	Select menu (event menu)
Content	A 3D object of a car engine lubrication system
	A 3D object of a car engine cooling system
	Learning materials

4.2. Design

The design stage is the stage of an embodiment of the structure application, interface design, and application storyboards. AR application design includes page interface opening to closing pages. The interface opening page consists of the main page with a choice of four menus or buttons, namely: the Augmented Reality button to view the Augmented Reality submenu; the Theory button to display the subject matter; About button to get instructions/information (help) on how to use the app, and the exit button is a menu option to exit the application (see figure 3). The interface design of this application follows the needs of the application and then develops the application flow or storyboard.

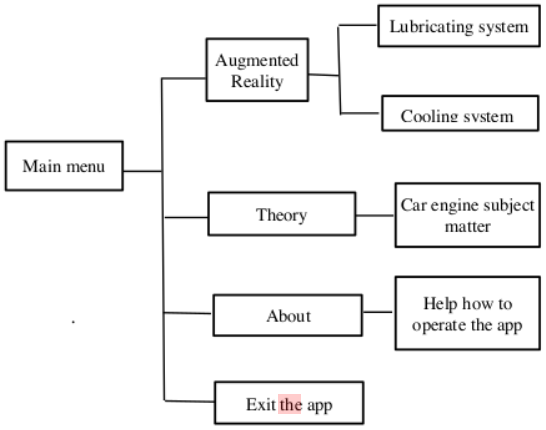

Figure 3. The Structure Program Application

4.3. Material Collecting

The material collecting stage is the stage of preparing the materials needed or used in the assembly stage, including software, hardware, and 3D objects of the lubrication system and car engine cooling system.

4.4. Assembly

The Assembly stage is the stage of making the application according to a predetermined design (at

the design stage). Finally, all materials collected are entered into the unity software for compilation. Meanwhile, the Quick Response (QR) Barcode Scanner to download the AR Media Education application program built in this study to an android phone is to execute a QR Barcode Scanner installed on an android phone while pointing the android cellphone camera to the barcode in Figure 4.

Figure 4. QR Barcode Scanner to download the AR Media Education application

The assembly for the Augmented Reality Educational Media application for Car Engine Lubrication and Cooling Systems are as follows: Figure 5 is the main menu display for the application. This main menu has an Augmented Reality button, a Theory button, an About (help) button, and a Cross button to exit the program.

Figure 5. Main Menu of Program Application

If the Augmented Reality button is pressed (selected), it will display the Augmented Reality Scan menu, which contains four menu buttons: the Cooling System button, Lubrication System, Return (back arrow button), and Exit (Cross arrow button), see figure 6. The back arrow button is helpful if the user returns to the previous menu page. The user is immediately directed to the last page if the Back arrow button is selected. Meanwhile, the Cross button is selected, meaning the user chooses to exit the application.

Figure 6. Augmented Reality Menu Page

Figure 7 shows the object's marker or barcode. When the user/learner presses the lubrication system button and then points the phone's camera at the marker or barcode, an object from the lubrication system will appear; then, the application program will display a 3D image of the car's engine cooling system. Then the application program emits a sound explaining the work of the car engine cooling system (see figure 8). Figure 9 describes the part name display of the Car Engine Lubrication System. Figure 9 appears when the user presses the Information button.

Figure 7. Object's Marker or Barcode

Figure 8. Lubrication System Camera Page

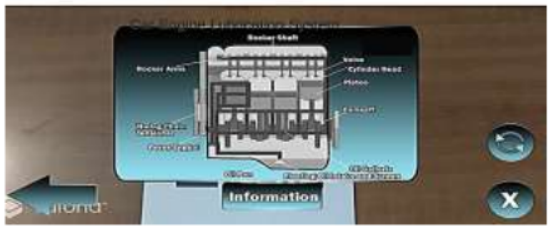

Figure 9. Display the Information page of the Car Engine Lubrication System

Figure 10. Cooling System Camera Page

Likewise, when the learner presses the cooling system button and then points the cellphone camera to the marker (barcode), a 3D object from the cooling system will appear and be accompanied by a voice explanation of the working process (see figure 10). Figure 11 displays the part names of the Car Engine

Cooling System. Figure 11 appears when the user presses the Information button.

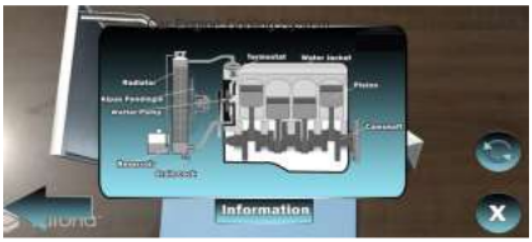

Figure 11. Display the Information page of the Car Engine Cooling System

Meanwhile, suppose the user presses the Theory button. Then, the application will display the theory menu of the subject matter with a choice of the main buttons: Cooling system and Lubrication system, and is also equipped with Back and Exit buttons (see figure 12).

Figure 12. Menu Page of Car Engine Theory

If the user presses the cooling system button, the user will enter the Cooling System course material page. Likewise, if the user presses the Lubrication System button, the user will go to the course material page of Lubrication System. The Back button allows the user to return to the previous page, while the Exit button is a button for the user to exit the application (see figure 13).

Figure 13. Page of Lubricant System Course Material

If the user presses the Cooling System button, the user will go to the course material page of Cooling System. The Back button allows the user to return to the previous page, while the Exit button is a button for the user to exit the application (see figure 14).

Figure 14. Page of Cooling System Course Material

4.5. Testing

The testing stage is a stage that aims to determine the extent of the suitability of the application made with the planned concept. In addition, testing also seeks to find errors that may exist in the application. Tests in this study used the Alpha test and Beta test methods. The authors do Alpha testing, while multiple users do Beta testing.

4.5.1. *Alpha test*

Alpha test is the process of checking or testing to determine if there are bugs or errors. The test results show that the AR application functions as it should or as expected. Table 3 shows the tested pages, test scenarios, and the results obtained from the Alpha test.

4.5.2. *Beta test*

The beta test is an advanced stage of the alpha test. The beta test aims to obtain data regarding users' feasibility level of the application. The number of samples for this Beta testing amounted to 30 students and a high school teacher as users of this Augmented Reality application. The measurement scale used in the Beta testing instrument uses a Likert scale with four multiple choices for students with a total of 6 questions (Q). Various answer choices for the Likert scale are strongly disagreed, disagree, agree, and strongly agree. Table 4 and Figure 14 show students/users' beta test results.

Beta Test on AR Educational Media built on students/users showed that most students/users answered strongly agree, and the rest answered Agree (see Table 4). It means, according to students/users, the AR learning media built has a high feasibility value in the following respects: AR learning media application is easy to use; The content in the AR learning media application is exciting and easy to understand; The AR learning media application does not error when used; The subject matter in the AR learning media application is easy to understand; 3D objects of the learning media application of AR appear when camera scan the marker (barcode); and AR learning media applications can help and facilitate students in learning the basics of car engine systems.

Table 3. Alpha Test Results On Application Pages And Scenarios Of AR Applications

No	Tested page / form	Scenario	Expected Results	Test results	
				In accordance	Not in accordance
1	Main Menu Page	The application displays the main menu containing buttons: Augmented Reality, Theory, About, and Exit	All these buttons can appear or function according to the existing scenario	✓	-
2	Main Menu Page	If the Augmented Reality button is pressed, it will enter the scan camera page Augmented Reality	It can lead to an Augmented Reality scan page	✓	-
3	Main Menu Page	If the Theory button is pressed, the user will enter a page containing material about car engine systems	Can lead to course material page	✓	-
4	Main Menu Page	If the user presses the About button, the user will go to a page that contains a user guide application	Can lead to the About page	✓	-
5	Main Menu Page	If the exit button is pressed, it will exit the application	Can exit the app	✓	-
6	Augmented Reality Scan page	All buttons works well according to application	All buttons work properly on Application	✓	-
7	Camera page	All objects appear when scanned	All Objects can appear when scanned	✓	-
8	Theory page	The material page displays the subject matter	The Theory page can display subject matter	✓	-
9	About page	The About page can show help	Can show hints or help	✓	-

Table 4. Beta Testing Results on Students/Users

Q	Questions	Answers to questions			
		Strongly disagree	Disagree	Agree	Strongly Agree
Q1	AR learning media application is easy to use	0	0	12	18
Q2	The content in the AR learning media application is exciting and easy to understand	0	0	10	20
Q3	The AR learning media application does not error when used	0	0	12	18
Q4	The subject matter in the AR learning media application is easy to understand	0	0	13	17
Q5	3D objects of the AR learning media application appear when the user scans the marker (barcode)	0	0	5	25
Q6	AR learning media applications can help and facilitate students in learning the basics of car engine systems	0	0	6	24

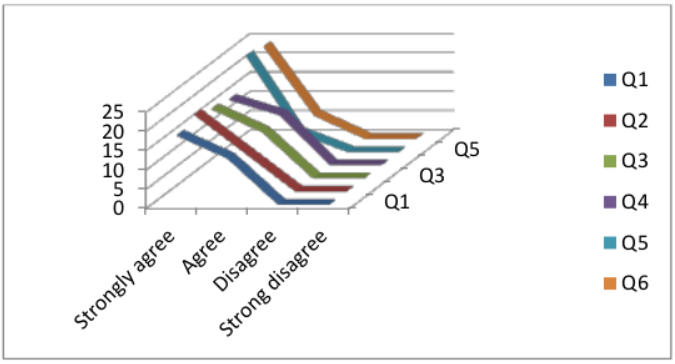

Figure 14. Beta Testing Results on Students/Users

Table 28 shows the value weight for each answer choice. Based on the results of the Beta test, the feasibility level of the application to users/students through the survey instrument is known as follows (see Table 6): The ease of using the AR learning media application has a feasibility (weighted score) of 90.0% of the total ideal eligibility of 100%. It means that the majority of students/users give an excellent score on the question AR learning media application is easy to use. Likewise, the results of beta trials on other feasibility of AR applications, namely: the content in the AR learning media application is exciting and easy to understand; The AR learning media application does not error when used; The subject matter in the AR learning media application is easy to understand; 3D objects in the learning media application of AR appear when you scan the marker (barcode), and AR learning media applications can help and facilitate students in learning the basics of car engine systems; all of them get very high scores.

Table 5. Weighting of Each Answer Choice

Answer	Score weighting
Strongly disagree	1
Disagree	2
Agree	3
Strongly agree	4

Table 6. Total students/users' assessment score for each survey question

Weight	Q1	Q2	Q3	Q4	Q5	Q6
4	72	80	72	68	100	96
3	36	30	36	39	15	18
2	0	0	0	0	0	0
1	0	0	0	0	0	0
Total Score	108	110	108	107	115	114
Total score in %	90.0%	91.6%	90.0%	89.1%	95.8%	95.0%

Meanwhile, the Beta testing conducted on teachers with interviews showed that the car engine system's primary learning media benefited teachers in teaching students. Besides that, the AR application of the car engine system is very suitable for classroom learning media.

4.6.Distribution

This distribution stage is a trial stage evaluating the learning outcomes obtained from the product being developed. The Shapiro-Wilk normality test of experimental class and traditional class learning outcomes data shows that the data is normally distributed. In this case, the significant value of the test results is greater than the alpha value of 0.05 for both Self-learning and traditional learning variables (see Table 7). The parametric statistical test t-test or comparative test between the independent variable self-learning and the face-to-face variable show that the significant level is 0.00 or lower in value than the alpha value (0.05). There is a significant difference in learning outcomes between independent and traditional face-to-face learning (see Table 9). Because the average value of learning from independent learning (80.73) is greater than the average value of face-to-face learning (66.5), it is concluded that the results of independent learning are better than the results of traditional face-to-face learning (see Table 8).

Table 7. The results of the normality test for independent study variable data and face-to-face traditional variable data

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SelfLearning	.129	30	.200*	.975	30	.687
F2F	.126	30	.200*	.967	30	.472

* is the lower bound of the true significance
a. Lilliefors significance correction

Table 8. The average value of the variable data of independent and face-to-face traditional learning outcomes

Type	N	Mean	Std. Deviation	Std. Error Mean
SelfLearning	30	80.7333	10.18428	1.85939
F2F	30	66.5000	12.80827	2.33846

Table 9. Independent t-test results of independent study variables and face-to-face traditional variables

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2 tailed)	Mean difference	Std. error difference	95% confidence interval of difference	
									Lower	Upper
Selfandf2f	Equal variances assumed	1.573	.215	4.76	.58	.000	14.23333	2.987	8.25	20.21
	Equal variances not assumed			4.76	56.2	.000	14.23333	2.987	8.24	20.22

Regarding the research question how the success of student independent learning on the AR learning", the results of this study indicate that students who learn independently through AR android are more successful than students who learn through traditional classroom learning. In other words, the results of this study reject the assumptions/views/hypotheses of some people [13] who state that independent learning is not a good substitute for traditional face-to-face classroom teaching. Instead, the results of this study indicate that in certain subjects, independent learning through AR media can replace traditional classroom learning. In short, AR-independent learning can be a reliable learning method in replacing face-to-face learning in class in developing students' cognitive knowledge. Thus the results of this study agree with the opinion of the previous researcher, C. Kairu (2021), that AR improves cognitive thinking in understanding lesson content [25]. Besides that, the findings of this study strengthen the opinion of R. Butson, ST. John, and A. Suazo (2020) [18] that independent learning is currently essential as a student learning method. These results also reinforce the opinion of previous researchers that AR learning media offers learning benefits for students who are no longer dependent on teachers' teaching in class [27].

5. Conclusion

Alpha test results show that the AR application functions according to the scenarios. Meanwhile, the Beta test results showed that most students/users strongly agree that: the AR learning media application is easy to use (the weight of the score reaches 90% of the ideal score); The content in the AR learning media application is exciting and easy to understand (the weight of the score up to 91.6% of the ideal score); The subject matter in the AR learning media application is easy to understand (the significance of the score up to 89.1% of the perfect score); 3D objects of the AR learning media application appear when the user scans the marker (the weight of the assessment reaches 95.8% of the ideal value), and AR learning media applications can help and facilitate students in learning the basics of car engine systems (up to 96% of the weight of the score from the ideal score). Furthermore, the results of open interviews with the teacher concluded that AR educational media for the lubricating and car engine cooling systems was beneficial and suitable for face-to-face learning media in the classroom. The results of the study show that students' independent learning is better than the learning outcomes of teachers teaching in the classroom. So, the implication is

that AR media can replace the teacher's role in teaching car engine cooling and lubrication systems subjects.

The results of this study strengthen the opinion of the previous researcher, R. Butson, ST. John, and A. Suazo (2020) [18], that independent learning is currently a very important student learning method. The results of this study also strengthen the opinion of experts D. Parsons and K. Maccallum (2021) that AR learning media offers learning benefits for students who can detach themselves from teaching skills. Besides that, the results of this study are in line with the previous researcher, C. Kairu (2021), who said AR increases cognitive thinking in understanding lesson content. But in contrast, the results of this study have rejected the assumptions, views, and hypotheses that say that independent learning is not suitable as a substitute for traditional face-to-face learning in the classroom. Another novelty of this research is that previous researchers have never studied and developed R&D, surveys, and experimentation on learning media for car engine lubrication and cooling systems with AR technology. For further research, it is necessary to carry out similar research on various other machines and develop learning media and other media such as machine repair animation media and try out other learning methods such as collaborative learning and flipped classroom learning.

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