ARCLearning: A Mobile Learning Application for TESDA Automotive Servicing Program

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Approval Sheet

TECHNOLOGICAL INSTITUTE OF THE PHILIPPINES – QUEZON CITY
College of Information Technology Education

ENDORSEMENT FOR ORAL PRESENTATION

This is to endorse the group composed of

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with project title *ARC Learning: A Mobile Learning App for TESDA Automotive Servicing Program* which has been assessed and evaluated by the undersigned, and after a thorough examination, the project has been found to have satisfactorily complied with all the Capstone/Thesis requirements of the College of Information Technology Education in terms of meeting the required objectives, solving the problems/issues stated, accomplishing the scope/features, and complying with the revisions/requirements of the panel.

MS. ROXANNE A. PAGADUAN
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Signature Over Printed Name of Adviser/Date

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Abstract

This paper presents the development of a mobile learning application for automotive programs that are accredited in TESDA and utilized the use of 3D Unity with augmented reality and SLAM Algorithm, This study aims to help the students in the field of the automotive industry program on how to visualize, learned in the module, analyze the object of the specific target and demonstrate how to use the mobile learning application with augmented reality, Agile methodology was used in this project, which will focus on planning, development, and deployment of the mobile learning application the acceptance and designing of the mobile application are done in developing the mobile learning application, The ARCLearning application was tested and evaluated by IT experts and Samson College students in the course of Automotive using the ISO 9126 evaluation tool. Based on the results of the evaluation the application has the Functionality, Usability, Reliability, Maintainability, Portability, and Efficiency. that the user needs. In addition, the platform that is available in the mobile application is an android phone.

Keywords: Mobile Learning, Augmented Reality, Automotive, Agile methodology, ISO 9126

Chapter 1

Introduction

Technological advancements are completely changing education nowadays. Portable tablets and smartphones are changing how people access and receive information, including instruction, worldwide. These tools make knowledge accessible, enabling students to get the most out of their instruction. Training is now more self-directed and relevant than ever. The automotive business can profit significantly from mobile applications. Applications can be used to monitor automobiles in real-time and to improve their built-in technologies.

Augmented Reality (AR) integrates digital information with the user's environment in real-time. Augmented reality applications in the automotive industry are used to help students to show car functionality. The technology allows for a visualization of lots of overlapping information about the parts of a vehicle.

Background of the Study

The world is changing rapidly, and the growth of knowledge is phenomenal. Knowledge is no longer limited to books, and the use of technology-related applications such as websites, apps, videos, live chats, etc., is increasing daily. Mobile learning through wireless mobile technology allows anyone to access information and learning materials anywhere and anytime (Ganesan et al., 2019).

According to Samson College of Science & Technology (2022), students had a hard time learning the parts and functions of an internal combustion engine which has resulted in the cut number of students enrolling to 50% due to the ineffectiveness of the online class conducted.

Professors are having difficulty keeping the students' attention during online classes. The most beneficial lesson to learn for automotive students is the Internal Combustion engine because it relates to the operation. Once the parts have been damaged, performance is affected stated by Dante Inocencio (personal communication, 2022).

Project Objective

The study's main objective is to develop a mobile learning application that will serve as a supplemental tool for TESDA Automotive Servicing Program.

Specifically, the study aims:

- Develop a mobile learning application that will utilize Augmented Reality (AR) in showing information such as internal combustion engine parts and functions.
- Apply simultaneous localization and mapping algorithm to the mobile application for the AR to overlay digital interactive augmentations.
- Evaluate the mobile application using ISO 9126 in terms of Functionality, Usability, Reliability, Maintainability, Portability, and Efficiency.

Significance of the Study

The application will benefit the following:

To the Student. Virtual or augmented reality may also be used as part of the curriculum for students in tech schools and those interested in a career in automotive. This study gives an advantage for students who are just learning the basics about car servicing, which has a unique feature to determine mistakes that can help the user to improve. Users can make errors without worrying about physical harm or other safety issues because any issue is safely contained in the virtual environment.

To the Samson College Automotive Program. The school signifies the application by providing it to the student who enrolled in automotive programs and using it as a mobile learning application that can help and guide the students in automotive programs.

To the Future Researchers. The app will be a reference for future developers taking the same course. The Future developers are free to modify or improve the project. This will serve as an opportunity for the developers to strengthen their planning and their skills in programming and development.

To Information and Communications Technology. Since the development is a mobile learning application, ICT can assist students in improving their programming and design skills. It should require good coding and graphic design knowledge for 3D model capabilities.

Scope and Delimitation

Scope

This system is designed to develop mobile learning applications with augmented reality features for the TESDA automotive program. The designed application will be composed of the following module(s):

List of ARCLearning Modules:

- Login and Signup
- Home
- Lessons
- AR Simulation
- Quizzes
- Students Progress Chart
- Tutorials

Student - Students' accounts can access the following modules:

- **Home -** Students can see their personal information and the profile of their instructor, including the contact details and course description.
- **Lessons -** Students can browse the topics under the internal combustion engine course.
- **AR Simulation** - Students can simulate the topics and augment the different parts of the engine.
- **Quizzes -** Students can take this to measure their learning of the different topics.
- **Tutorials -** This module will help or guide the students in using the application.

Instructor - Instructors' accounts can access the following modules:

- **Home** - Instructors can see their personal information and the course description.
- **Lessons** - Instructors can browse the topics under the internal combustion engine course.
- **AR Simulation** - Instructors can simulate the topics and augment the different parts of the engine.
- **Students' Progress Chart** - Instructors can see the grade of the students on the quizzes.

Delimitation

The proposed mobile application for TESDA automotive servicing is not capable of doing the following:

- This mobile application does not cover any other curriculum but is only related to the TESDA automotive program.
- This mobile application can operate to at least android operating system version 8.0.
- The project is limited to the internal combustion engine.

Chapter 2

Theoretical Framework

This chapter presents the related literature and studies of ARCLearning: A Mobile Learning Application for TESDA Automotive Servicing after the researchers' hard work and in-depth search. This part of the chapter also presents the construction of the application and its theoretical and conceptual framework to understand the research/application fully. This section also includes discussions of the operational terms used.

Review of Related Literature

Fernando R. Pusda, Francisco F. Valencia, Victor H. Andaluz, and Victor D. Zambrano (2019) propose the creation of an augmented reality application for Android mobile devices that focuses on the user's visualization and interaction with the parts, technical specifications, location, and processes of engine disassembly and assembly in a vehicle; this will aid in the learning process about automotive systems. They propose to use 3D Unity and Vuforia, which we will use as our primary software to develop ARCLearning Mobile Application.

According to Dr. Alex Heiphetz, Ph.D. (2017), Cellular communication technology, sometimes known as mobile technology, has exploded into the business culture more quickly than many organizations can enjoy the benefits. Businesses are rapidly utilizing mobile technology in several locations and for various reasons, including wireless networks and personal communication devices. ARCLearning found that many students are using mobile phones to educate themselves, and mobile learning is becoming more convenient and effective nowadays.

As stated by Washington X. Quevedo, Jorge S. Sánchez, Oscar B. Arteaga, Marcelo Alvarez, Víctor Danilo Zambrano, Carlos R. Sánchez and Víctor H. Andaluz (2017) in their study. They talk about a virtual training program for identifying and assembling car parts. The system is made up of a virtual reality environment created with the Unity 3D graphics engine, which enables the user to become more immersed in the teaching-learning process to, among other things, optimize resources like materials, infrastructure, and time. The user can choose the training process's work environment and degree of difficulty using the proposed technology. ARCLearning found that the outcomes of this study demonstrate the effectiveness of Augmented Reality (AR) in improving automobile mechanical skills.

Augmented reality in the automotive industry, particularly during inspection and maintenance. The employment of advanced technology is made possible to reduce manufacturing time, increase efficiency, and reduce costs. (Halim A, 2018). Augmented reality makes you learn errors by doing it virtually so that you will not apply it to a physical vehicle.

According to Zdeněk Čujan, Gabriel Fedorko, Nikoleta Mikušová in (2020). Virtual reality is now used in engineering. It is widely utilized across many industries. It opens up new avenues that boost production efficiency and dependability while improving product and process quality. Logistics is one of the industries utilizing virtual reality more and more. ARCLearning found this study, Augmented Reality (AR) in particular, provides the logistics sector with a way to improve the effectiveness of processes. Augmented Reality (AR) has many uses in the automotive logistics industry.

The way we learn is rapidly changing in the modern era of technology, and professionals and researchers worldwide are turning to augmented reality as one of their go-to teaching tools. Although it has been noted from previous studies that automotive engineers, researchers, students, and experts require various sources, such as books, simulation kits, and websites, to gather and learn information about the automotive industry and the production of various engine parts, it may be a time-consuming task and an antiquated method. In this paper, we developed real-time 3D models of various engine components using the 3D design software Blender and SolidWorks, and we also used TensorFlow and machine learning to identify vehicle elements. (Sallar J et al., 2019). ARCLearning found this study to be our guide and reference for designing a 3D model in a blender and all the information needed.

According to Nina Uljanić (2019), A developing technology, augmented reality, is used in many fields to support and direct labor. The automotive industry is one area where AR in practical applications is not widespread. The given research sought to assess the demand for augmented reality (AR) in the automobile sector and present an artifact adaptable to specific workshop settings to close this gap. The interviews illustrate the necessity for a mobile augmented reality tool in an industrial setting, and the tool's evaluation shows the advantages of integrating such technology into a workshop. ARCLearning found out in this study that detecting marks on cable connectors using augmented reality technology is more accessible, implying that more research is needed to advance this field on a bigger scale.

Augmented reality (AR) is a relatively new technology that allows people to engage with machines by projecting virtual data onto actual surroundings. In recent years, there have been numerous study topics with potential applications. This paper synthesizes 55 studies from 2002 to 2019 to comprehensively overview current AR systems in the automotive industry. The primary study questions are: where has augmented reality technology been used in the automotive sector, for what reasons, what are the defining traits of these systems, and what are the key advantages and difficulties of doing so? (Razvan Boboc et al., 2020) ARCLearning aims to give insight into augmented reality (AR) technologies and applications in the automobile industry.

The E-learning standard is composed of numerous distinct quality components and traits. Researchers looked into e-efficiency learning from a range of angles. There is not much research, though, specifically on the caliber of mobile applications for e-learning. Therefore, the current study examines the variables that affect how Al-Zaytoonah University students and teachers use the E-learning mobile application throughout the academic year 2020–2021. (Jaber K et al., 2021). ARC Learning found that this study shows how practical the mobile learning application is nowadays.

According to James, in June 2022, The automotive business can profit significantly from mobile applications. Applications can be used to monitor automobiles in real-time and to improve their built-in technologies. Why should makers of mobile applications consider this market seriously? Mobile app developers can monetize their apps by creating automotive apps. The automobile app is more extensive and will have longer-term effects. Additionally, by working with suppliers of third-party products, you may take advantage of the ecosystem and become one of the first market leaders in this highly lucrative sector. ARCLearning found in this study that mobile learning applications in the automotive industry have considerable potential.

Conceptual Framework

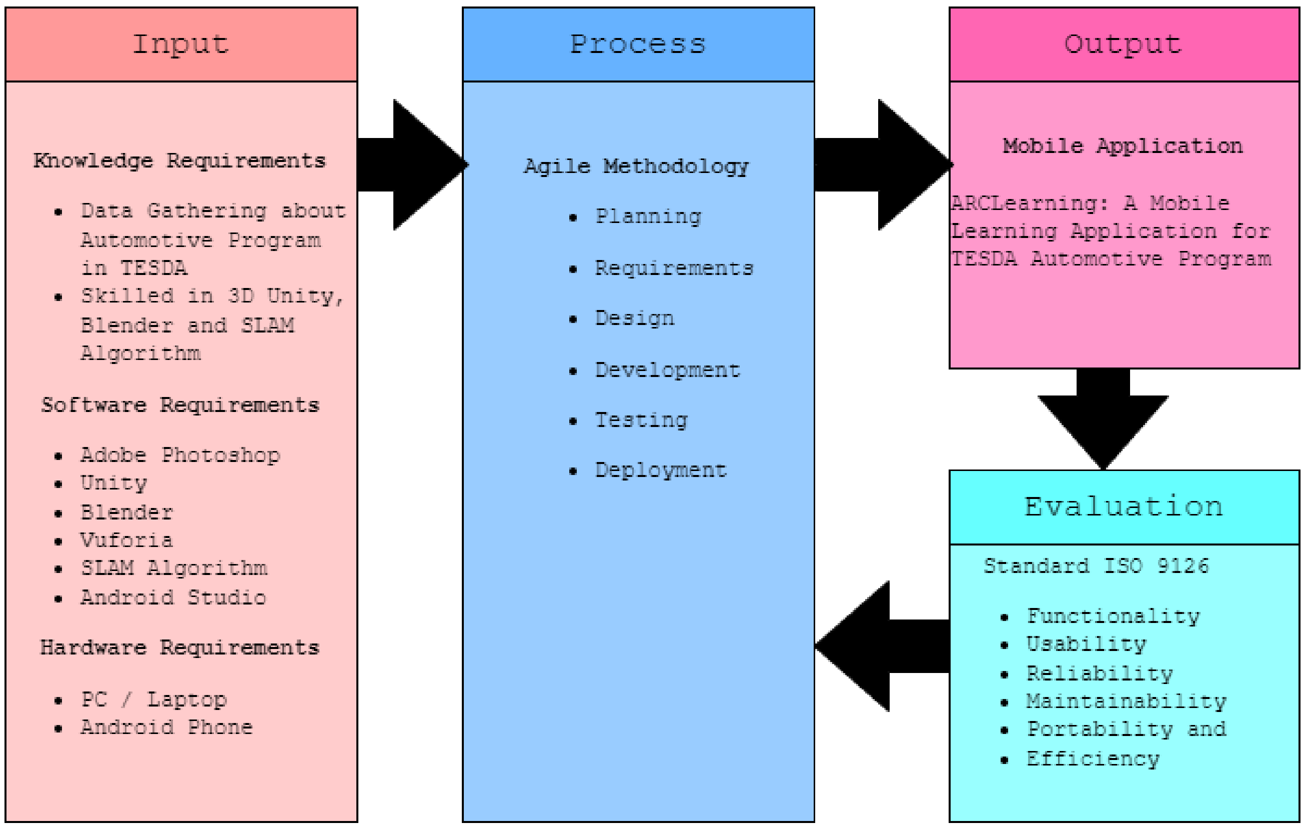

Figure 1. Conceptual Framework

Figure 1 shows the conceptual framework of ARCLEARNING, a mobile learning application where it has its input, process, output, and evaluation. The figure contains the input needed to make the project, the process of developing the project, the output of the project, and the evaluation method that the project will go through. The input represents what knowledge, software, and hardware requirements are needed for the project. All the inputs are going to use in the next phase. The process and components comprise steps and phases in the application development, which is based on the Agile Methodology Development approach. Lastly, the output developed a mobile application, and its evaluation based upon standards of ISO 9126 focused on functionality, usability, reliability, maintainability, portability, and efficiency.

System Architecture

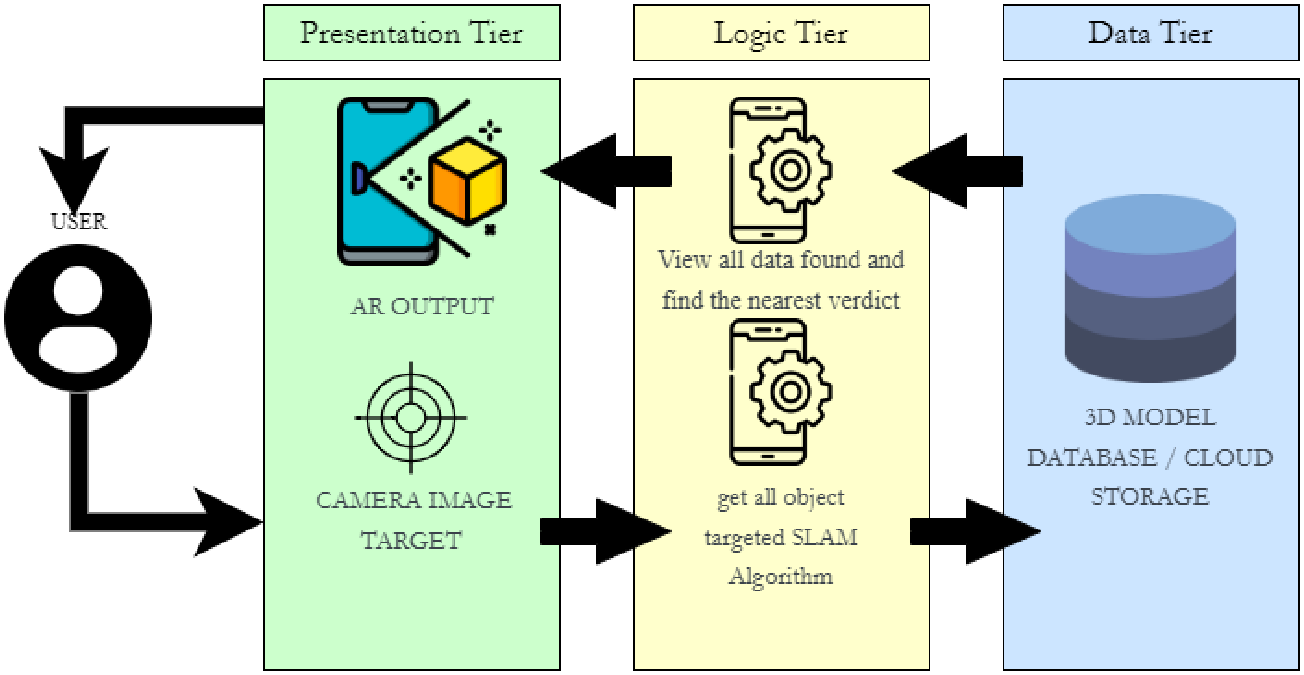

Figure 2. System Architecture

Figure 2 illustrates the process between the user and the mobile application. The system architecture's presentation tier is the user interface. The logic Tier is the ARCLearning that will target the nearest object to query it and will be sent to the SLAM Algorithm. It will be sent back and evaluated in the tier to have a result and get back to the user interface to view the information of the nearest object target. The user will need to use a camera-equipped device such as an android phone at a target vehicle, the object vehicle using augmented reality. Augmented reality will start when a user points the camera at a target vehicle. The mobile application recognizes it through computer vision technology then the user can view the augmented 3D object in the mobile application and display overlaying information about the target vehicle.

Definition of Terms

3D Unity - create 3D games and applications for mobile, desktop, the web, and consoles.

Augmented reality - is an experience where designers enhance parts of users' physical world with computer-generated input.

Automotive industry - all those companies and activities involved in manufacturing motor vehicles, including most components, such as engines and bodies, but excluding tires, batteries, and fuel.

Blender - Blender is the Free and Open Source 3D creation suite. It supports the entirety of the 3D pipeline, modeling, sculpting, rigging, 3D and 2D animation, simulation, rendering, compositing, motion tracking, and video editing.

Mobile application - software designed to run on a mobile device, such as a smartphone or tablet computer.

SLAM - A technology called SLAM (simultaneous localization and mapping) interprets the physical world using feature points. This enables AR applications to Instantly Track the environment, Recognize 3D Objects & Scenes, and Overlay Digital Interactive Augments.

TESDA - mandated to Approve skills standards and tests; Develop an accreditation system for institutions involved in middle-level workforce development; Fund programs and projects for technical education and skills development; and. Assist trainers in training programs.

Vuforia - is a software development kit (SDK) for creating Augmented Reality apps.

Chapter 3

Research Methodology

The research and design are covered in this chapter. Furthermore, this is where the researcher needs to come up with a method or ways to view the tool that was used, the data collection process, and the statistical components that were applied. The primary goal of this study is to support students enrolled in automotive programs. To meet the data collection or gathering requirements, we have established a few methods and tried to demonstrate how the application we created works.

Project Design

There will be a variety of tools employed in the creation of this project. Vuforia, Unity 3D, and Blender will be utilized to create the 3D model that will be enhanced, and Android Studio will be used as an integrated development environment to create the mobile application. Additionally, Adobe Photoshop will create unique visuals for the mobile application's user interface. Last but not least, the primary algorithm for this project will be the simultaneous localization and mapping method (SLAM). SLAM is a computer vision system that maps and tracks the environment by comparing visual elements between camera frames.

Design Discussion

The ARCLearning mobile learning application has three different design options, Light Design, Moderate Design, and Heavy Design,

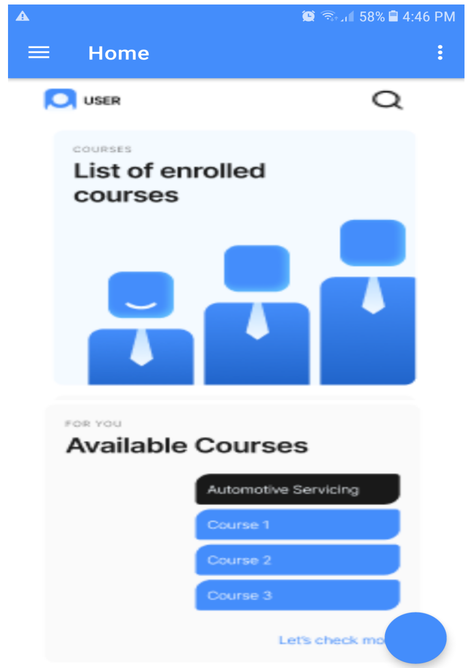

Figure 3. Design 1 - Light design style

For design 1, we used a solid blue color as the whole color theme of the application. We placed a user button on the upper right and a search button beside it. We added two more buttons in the middle for the list of enrolled and available courses. Lastly, the floating widget serves as a button for messaging.

Figure 4. Design 2 - Moderate design style

For design 2, figure 4 above shows a Moderate Design for mobile learning applications. It has a moderate design, with only 2 primary background colors, the avatar of the student, and four separate buttons. The first is the announcement button, and below is the module 1, 2, and 3

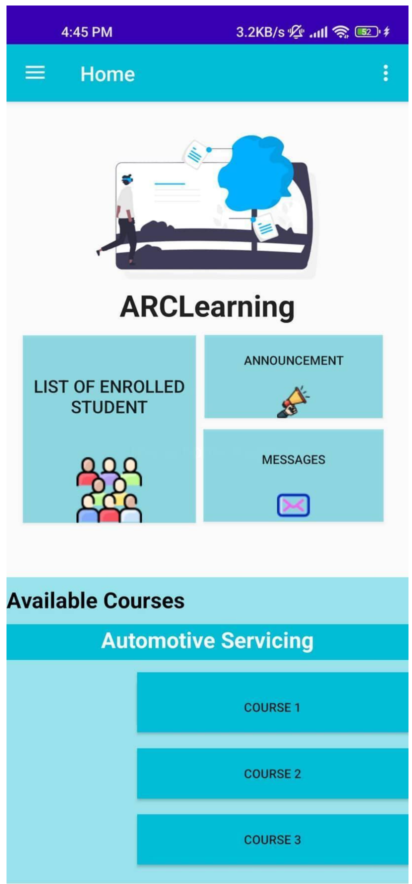

Figure 5. Design 3 - Heavy design style

For design 3, figure 5 above shows the heavy design for mobile learning applications. It has a heavy design with a solid teal color, a navigation drawer, 3 Buttons with each description, and Icons. I also added 3 different buttons for each course.

Design Trade-Offs

The criteria were separated into three (3) sections: File Size, Response Time, and Loading time. The File Size, also known as Storage Size, defines the application's actual storage after installation. Load time and speed are two of the most crucial metrics. Mobile app load time can be defined as the amount of time taken by the app to completely initialize before the interface opens and the app becomes actionable or clickable for the user. The Response Time, known as processing time, is calculated by counting the seconds a CPU spends processing instructions from an application or your operating system. A higher number indicates that the system is busy or overloaded.

Table 1. Summary of Constraint

Design	Design Constraint		
	File Size	CPU Usage	Loading Time
Design 1 - Light Design style	5.78MB	0.252MB	1.02s
Design 2 - Moderate Design style	5.83MB	0.302MB	3.20s
Design 3 - Heavy Design style	7.37MB	0.353MB	1.77s

Table 1 shows the summary constraint of three different designs, including designs 1, design 2, and design 3, as well as the investigated design constraints, which are File size, Loading Time, and Response Time. In Design 1, the file size is 201B, the loading time is 57ms, and the response time is 329ms. Design 2 has file size, loading time, and response time. Lastly, design 3 has 201B filesize, 350 loading time, and 500ms for response time.

To determine the most suitable design to use the design trade-offs were conducted.

$$\%\ difference\ for\ MIN = \frac{(HighValue\ -\ LowerValue)}{HighValue}$$

$$\%\ difference\ for\ MAX = \frac{(HighValue - LowerValue)}{HighValue}$$

Equation 1. The equations above show the difference percentage formula to get the MIN and MAX

$$Subordinates\ Ranks = Government\ Ranks - (\%\ difference * 10)$$

Equation 2. Equation 2 shows the formula to get the Subordinate's Ranks

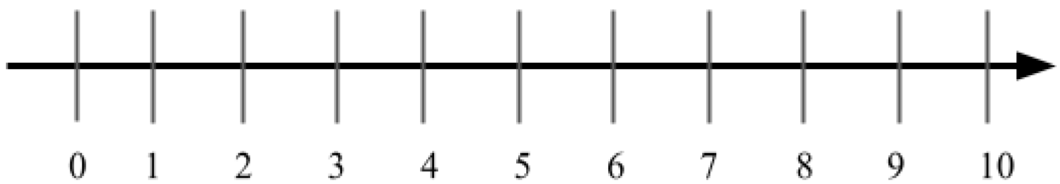

Figure 6. Ranking Scale

The figure above indicates the difference between the two designs that will be compared.

Trade-off 1: File Size

Table 2. File Size

Design	File Size
Design 1	3.8kb
Design 2	2.3kb
Design 3	19.3kb

The table 2 shows the comparison between the three designs of mobile application File Size. design 2 is the lowest consumption of file size, and design 3 is the highest memory usage due to the heavy design style of the application.

Design 1 and Design 2:

$$\%\ difference\ MIN = \frac{(3.8 - 2.03)}{3.8}$$

$$\%difference = 0.46$$

$$Subordinates\ Ranks = 10 - (.46) * 10$$

$$Subordinate\ Ranks = 5.4$$

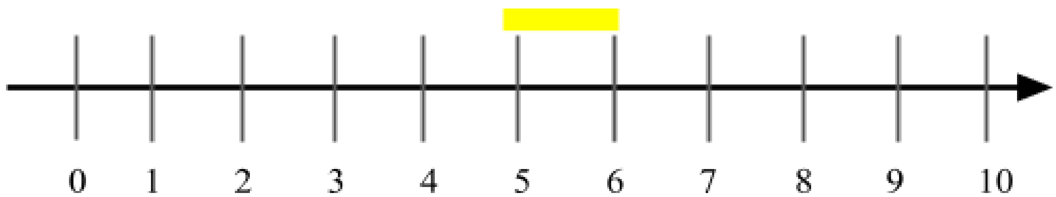

Figure 7. Subordinate Rank: Design 1 and Design 2

Figure shows the difference between design 1 and design 2 is 46%

Design 2 and Design 3:

$$\%\ difference\ MAX = \frac{(19.3 - 2.03)}{19.3}$$

$$\%difference = .89$$

$$Subordinates\ Ranks = 10 - (.89) * 10$$

$$Subordinates\ Rank = 1$$

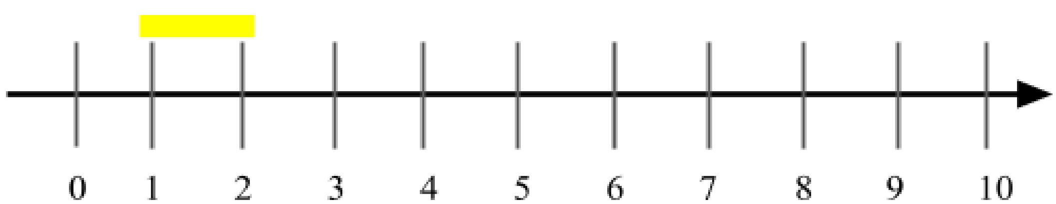

Figure 8. Subordinate Rank: Design 2 and Design 3

Figure shows the difference between design 2 and design 3 is 89%

Trade-off 2: Loading Time

Table 3. Loading Time

Design	Loading Time
Design 1	0.792s
Design 2	0.573s
Design 3	0.161s

In table 4, it shows the comparison of the three (3) designs in terms of the frequency of the Loading Time of the simulation. Design 3 got the lowest Loading Time and was considered as the governing rank and will be given a value of 10.

Design 2 and Design 3:

$$\%\ difference\ MIN = \frac{(0.573 - 0.161)}{0.573}$$

$$\%\ difference = 0.71$$

$$Subordinates\ Ranks = 10 - (0.71) * 10$$

$$Subordinates\ Ranks = 2.9\ or\ 3$$

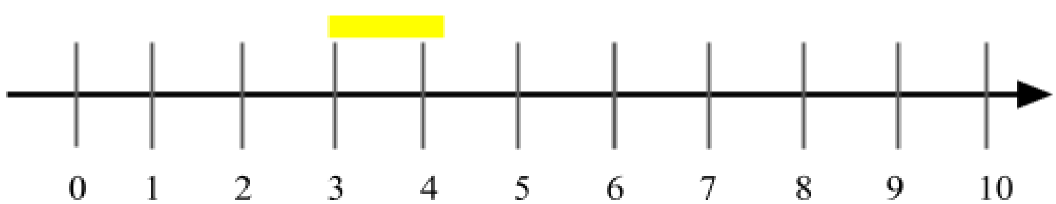

Figure 9. Subordinate Rank: Design 2 and Design 3

Design 1 and Design 3

$$\%\ difference\ MAX = \frac{(0.792 - 0.161)}{0.792}$$

$$\%\ difference = .80$$

$$Subordinates\ Ranks = 10 - (0.80) * 10$$

$$Subordinate\ Ranks = 2$$

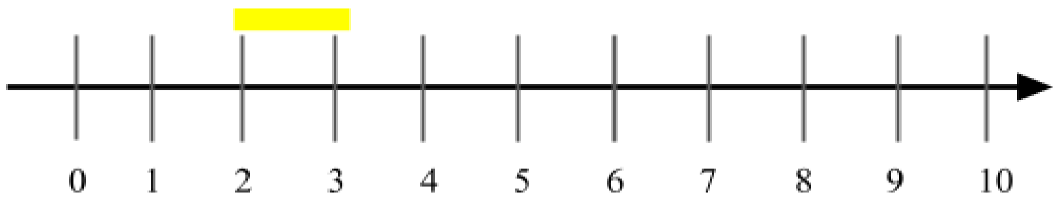

Figure 10. Subordinate Rank: Design 1 and Design 3

Trade-off 3: Response Time

Table 4. Response Time

Design	Response Time
Design 1	0.9141s
Design 2	0.329s
Design 3	0.487s

The table 4 shows the comparison of the three designs in terms of the Response of the Response time, Design 1 got the highest response time while the design 2 has lowest response time and can be considered as the governing rank and will be given a value of 10

Design 3 and Design 2:

$$\%\ difference\ MIN = \frac{(0.487 - 0.329)}{0.0487}$$

$$\%\ difference = 0.32$$

$$Subordinates\ Ranks = 10 - (0.80) * 10$$

$$Subordinate\ Ranks = 6.8\ or\ 7$$

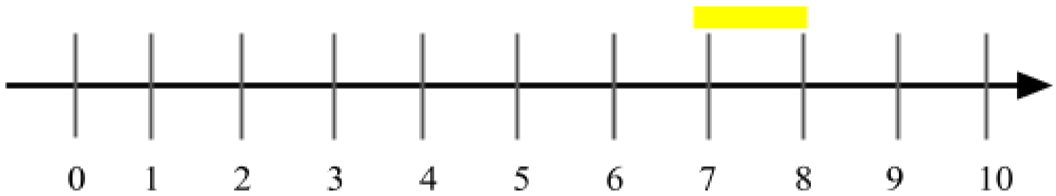

Figure 11. Subordinate Rank: Design 3 and Design 2

Design 1 and Design 2:

$$\% \ difference\ MIN = \frac{(0.914 - 0.329)}{0.914}$$

$$\% \ difference = 0.65$$

$$Subordinates\ Ranks = 10 - (0.65) * 10$$

$$Subordinate\ Ranks = 3.5$$

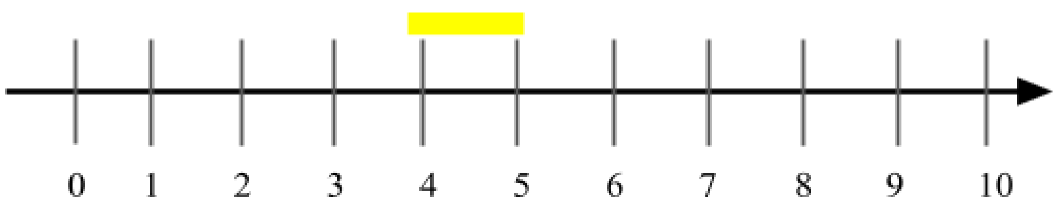

Figure 12. Subordinate Rank: Design 1 and Design 2

Criterion's Performance

After analyzing the three designs based on the three different constraints, table 5 shows the overall rank of each criterion that has been calculated. It is to determine the most suitable design for the application.

Table 5. Overall Ranking of each Criterion

Decision Criteria	Criterion's Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	10	5	10	1
2. Loading Time	8	2	3	10

3. Response Time	9	4	10	7
Overall Ranking		102	214	136

The criterion is ranked based on its level of importance. A value of 10 is given to File Size because it is where to see that the application requires a faster execution time in loading or processing results after the simulation process. A value of 8 is given to Loading Time, it is to determine what particular design is compatible and runnable to a certain frequency before the deployment of the entire system. Lastly, a value of 9 is given to Response Time, it is to decide what particular design could be done the soonest time possible.

Sensitivity Analysis

Sensitivity analysis is a method used to determine how the variation in the output of a model can be attributed to changes in the input variables. It is used to identify which input variables have the greatest impact on the output, and can help to determine the model's overall robustness.

1st Combination for Sensitivity Analysis

Table 6. Sensitivity Analysis Using 10-8-9 Criterion Rank

Decision Criteria	Criterion's Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	10	5	10	1
2. Loading Time	8	2	3	10
3. Response Time	9	4	10	7
Overall Ranking		102	214	136

In table 6, the combination of 10-8-9 was used in the criterion's importance. The design 2 got an overall rank of 214, 102 for design 1 and 136 for design 3.

2nd Combination for Sensitivity Analysis

Table 7. Sensitivity Analysis Using 8-9-10 Criterion Rank

Decision Criteria	Criterion's Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	8	5	10	1
2. Loading Time	9	2	3	10
3. Response Time	10	4	10	7
Overall Ranking		96	207	168

In table 7, the combination of 8-9-10 was used in the criterion's importance. The design 2 got an overall rank of 207, 96 for design 1 and 168 for design 3.

3rd Combination for Sensitivity Analysis

Table 8. Sensitivity Analysis Using 10-9-8 Criterion Rank

Decision Criteria	Criterion's Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	10	5	10	1
2. Loading Time	9	2	3	10
3. Response Time	8	4	10	7
Overall Ranking		100	207	156

In table 8, the combination of 10-9-8 was used in the criterion's importance. The design 2 got an overall rank of 207, 100 for design 1 and 156 for design 3.

4th Combination for Sensitivity Analysis

Table 9. Sensitivity Analysis Using 9-10-8 Criterion Rank

Decision Criteria	Criterion's Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	9	5	10	1
2. Loading Time	10	2	3	10
3. Response Time	8	4	10	7
Overall Ranking		97	200	165

In table 9, the combination of 9-10-8 was used in the criterion's importance. The design 2 got an overall rank of 200, 97 for design 1 and 165 for design 3.

5th Combination for Sensitivity Analysis

Table 10. Sensitivity Analysis Using 8-10-9 Criterion Rank

Decision Criteria	Criterion's Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	8	5	10	1
2. Loading Time	10	2	3	10
3. Response Time	9	4	10	7
Overall Ranking		96	200	171

In table 10, the combination of 8-10-9 was used in the criterion’s importance. The design 2 got an overall rank of 200, 96 for design 1 and 171 for design 3.

6th Combination for Sensitivity Analysis

Table 11. Sensitivity Analysis Using 9-8-10 Criterion Rank

Decision Criteria	Criterion’s Importance	Ability to satisfy the criterion (0 to 10)		
		Design 1	Design 2	Design 3
3. File Size	9	5	10	1
2. Loading Time	8	2	3	10
3. Response Time	10	4	10	7
Overall Ranking		101	214	159

In table 11, the combination of 9-8-10 was used in the criterion’s importance. The design 2 got an overall rank of 214, 101 for design 1 and 159 for design 3.

Project Development

Agile modeling was the methodology employed by the project's proponents in creating ARC Learning: A Mobile Learning App for the TESDA Automotive Program. The term "Agile Model Process" refers to an iterative development-based approach to software development, and the word "agile" has a rapid or adaptable connotation. Agile methodologies break down more extensive processes or components into smaller ones that do not require direct long-term planning. The project's needs and scope are outlined at the beginning of the development phase. Plans are made expressly in advance regarding each iteration's number, duration, and scope.

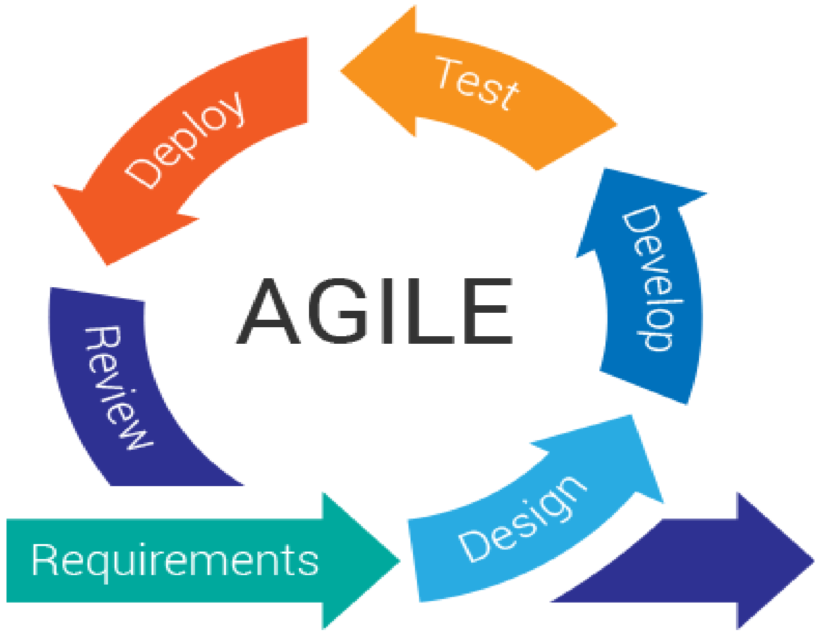

Figure 13. Agile Development Model

Requirements Phase - The initial user problems that can be solved are prioritized and gathered. Transform the needs and high-level requirements developed in previous phases into precise (measurable and testable), traceable, comprehensive, consistent, and user-approved specifications.

Design Phase - The design process of the paradigm begins with conceptual design and progresses through systematic design, logical module design, physical product design, and final design in the model's middle stage.

Development Phase - The development phase is when the system product is built on the system model. A prototype is created in this phase to collect user feedback when the product is merely being thought of, and the design is being developed. Then, in the implementation phase of the model, with more clarity on requirements and design specifics, a functional model of the program called to build with a final version is developed.

Testing Phase - The user analyzes the system and offers comments after testing the build after the first iteration.

Deployment Phase - The completed version of the product was launched in the market. Newer changes and features are integrated, and maintenance for some system changes if occur.

Review Phase - this is the last stage of the Agile development cycle. After completing all the previous stages of development, the development team presents to the owner the result achieved in meeting the requirements.

Testing and Operating Procedure

Usability testing, often known as user experience testing, is an evaluation technique that assesses how user-friendly and straightforward a software product is. Use a software tool to pinpoint usability issues for a select group of intended end-users. Utility testing emphasizes how user-friendly applications are, how adaptable they handle controls, and how capable they are of achieving their goals. This test is suggested during the initial SDLC design phase since it provides a clearer picture of users' expectations. Users' satisfaction is the primary focus of this testing, which primarily focuses on a system's efficacy, efficiency, accuracy, and user-friendliness.

Project Evaluation

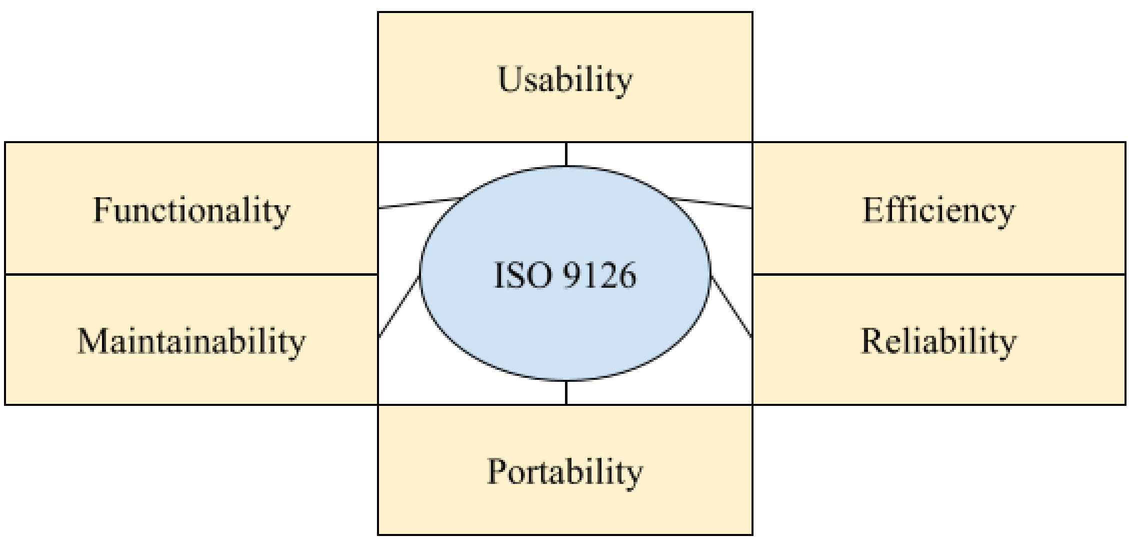

Figure 14. ISO 9126 Software Quality Characteristics

The application was evaluated with a guide from the International Organization for Standardization. The ISO standard category that will serve as a guide is ISO 9126 or Software Quality. The target users are

Automotive students and or Faculty professors of Samson College who will test the application's functionality, usability, efficiency, reliability, and accuracy. The functionality quality of a software product is used to evaluate and define the quality of a software product. It includes the sub characteristics of functionality, suitability, accuracy, and student security.

Work Plan

Table 12. Work breakdown structure

Phase	Assign Member	Schedule									
		Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023
1. Requirement Phase											
1.1 System Requirements	Team										
1.2. Project needs	Team										
1.3 Project approval	Team										
2. Design Phase											
2.1 build wireframe	in progress										
2.2 finalize design	in progress										
3. Development Phase											
3.1. coding	in progress										
3. 2. designing	will start										
4. Testing Phase											
4.1 evaluate error	will start										
4.2 project testing	will start										
4.3. functionality testing	will start										
5. Deployment Phase											
5.1. finished app	will start										
5.2. bring out app	will start										
6. Review Phase											
6.1. error handling	will start										
6.2. analyze outcome	will start										

LEGEND: DONE | In progress | will start

The team's work plan is broken down in Table 12. This work plan was created using the agile technique. We first entered the planning and requirement analysis phase to identify the requirements we must meet. The second is design; we created layouts and sketches for how the user interface should appear and where to place each module. The third step is development, which comes after having the design and before implementing all of the functionalities. Fourth, we examined every conceivable input and verified that the system produced the desired results. The completed project must be prepared for testing and release as the fifth requirement.

Potential for Commercialization

This mobile learning application was created specifically for mobile devices, particularly Android phones. The mobile applications aim to help the student see the virtual object and 3D model of the automotive parts of the vehicle, and also this application will also serve as an insight into their programs or studies. This will assist them in realizing how the various skills and knowledge acquired in this program will benefit their future jobs.

Market Model

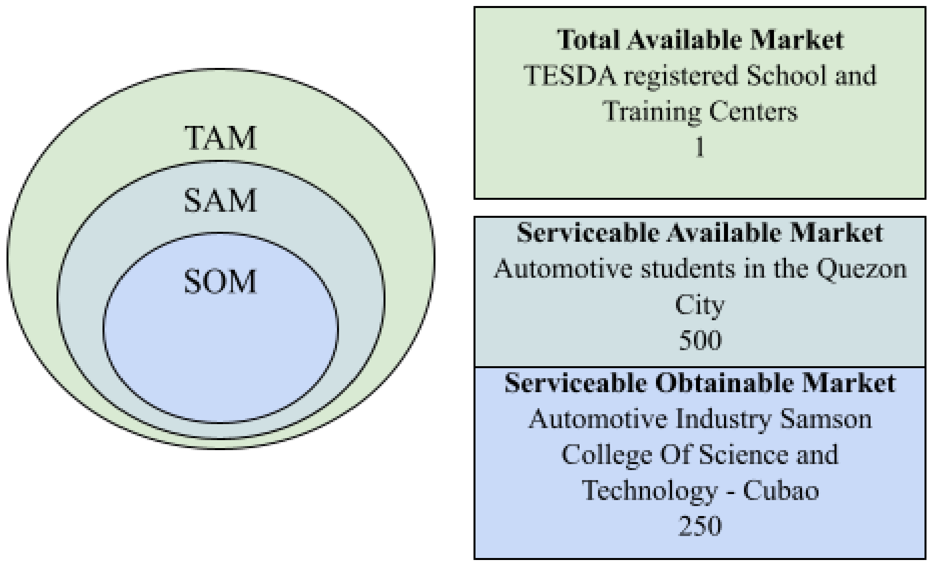

Figure 15. Market Model

The market model above shows the Total Available Market (TAM), Serviceable Available Market (SAM), and the Share of Market (SOM) potential market of the application ARCLearning app for the TESDA Automotive Servicing Program.

TAM - According to the TESDA Quezon City District Office (QCDO), only 1 school is registered with the TESDA Automotive Program.

SAM - According to the Samson College Of Science and Technology - Cubao, there are 500 total automotive students.

SOM - The current number of students enrolled in the Automotive Program in Samson College of Science and Technology - Cubao is 250.

Measurable Benefits

Table 13. Measurable Benefits

Continual Improvement	The application can provide on-hand specific information to the targeted vehicle
Student	The applications help the student to view the 3D Model object of the vehicle using augmented reality.
Learning Methods	The applications also serve as their tool in mobile learning about the automotive program

Table 13 shows the measurable benefits of the application to the user. It will serve as the tool for the user to experience augmented reality in the automotive industry. This application will also benefit the following, efficiency, effectiveness, student, and Learning Methods. The goal of the applications is to help the automotive student program to act for their study in the automotive industryThree-year Product Roadmap.

Three-Year Product Roadmap

Table 14. Three-Year Product Roadmap

	Year 1	**Year 2**	**Year 3**
Price	Free	Free	Free
Key Features	• Augmented Reality • Information about Object Model • Automotive Modules	• Realistic • More information about object	The accuracy of the augmented object in automotive
Market	Samson College - Cubao	Quezon City	TESDA Registered Schools and Training Centers
Platform	Android	Android	Android

Table 14 shows what will be the possible plan and improvements for the first three years of the application.

Go-to-Market Strategy

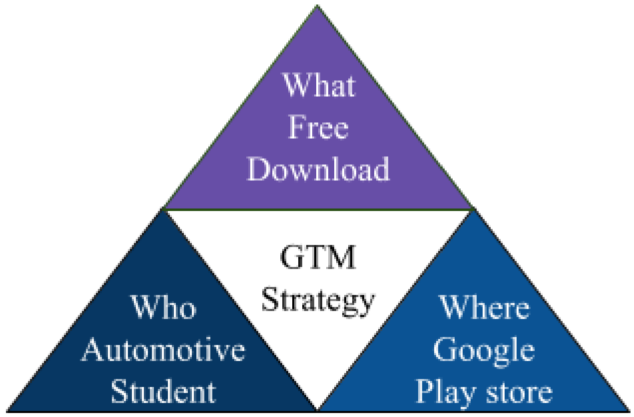

Figure 16. Go-To-Market Strategy

For the application's Go-to-Market strategy, the project's main target is Automotive students. The Deployment of the application can be an advertisement and can be downloaded for free on Google Play Store

Business Model

Table 15. Business Model

<table>
<tr>
<td rowspan="2">Key Partners
• TESDA QCDO
• Samson College</td>
<td>Key Activities
• UI Design
• Software Development</td>
<td rowspan="2">Value Propositions
• Augmented Reality
• 3D Object
• Provide Information</td>
<td>Customer Relation
• Automotive Student
• feedback, suggestion, and comments</td>
<td rowspan="2">Customer Segments
• Automotive Student
• Faculty Professor
• Automotive Industry</td>
</tr>
<tr>
<td>Key Resources
• Android Studio
• Vuforia
• Blender
• Unity 3D</td>
<td>Channel
• Google Play store
• Ads in TESDA QCDO</td>
</tr>
<tr>
<td colspan="2">Cost Structure
• Development Cost
• Maintenance Cost</td>
<td colspan="3">Revenue Streams
• Ads Revenues
• School Ads</td>
</tr>
</table>

Chapter 4

Result and Discussion

This chapter describes the results of the evaluation of the project. This part discusses the Project description, project structures and project evaluation.

The developers will conduct an evaluation to test the ARCLearning application to respondents. The developers used and based the evaluation on the standard evaluation tool ISO 9126 in terms of Functionality, Usability, Reliability, Maintainability, Portability, and Efficiency.

Additionally, the data collected will be used to analyze the mobile learning application if it meets the objectives of helping the students in samson college in the course of automotive program to help and learn more knowledge about automotive in internal combustion.

Project Description

ARCLearning is a mobile learning application that will help the student in Samson College in the course of Automotive Program to teach, learn and at the same time, experience the Augmented Reality of the application. The quiz aims to determine what the user has to learn in the lesson. The application also has a video recording that will help the student to visualize the internal combustion and also remember what the user learns from the lesson. The user also experiences Augmented Reality, is an interactive experience that enhances the real world with the mobile-generated perceptual information, it overlays the digital object models of specific parts of internal combustion onto real-life environments. The application was developed through the partnership of Samson College Of Science and Technology and Technological Institute of the Philippines (TIP-QC).

Development Discussion

ARCLearning is a mobile learning application created for Samson College students and instructors. Specifically in the Automotive program, which may only be used on a mobile device The ARCLearning team developed a mobile learning application that includes videos, text, and 3D objects and models of internal combustion objects. Includes the necessary Internal Combustion modules according to the Teaching and Learning course syllabus. In addition, we looked for works that are similar to the automotive application that was implemented in a mobile application. and deployed the SLAM, while implementing the Agile Process in the project development of our application.

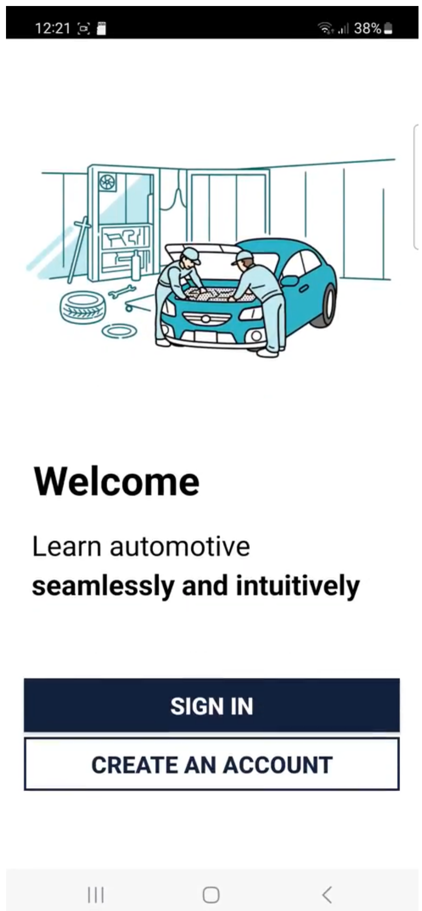

Figure 17. **Welcome**

Figure 17 shows the Welcome Interface of the mobile learning application, this module has a signin that will accept the username and password from the user and will be verified using the firebase database, and create an account, interface allows the user to input personal data which is needed to create a user's account allowing them to log into the system. The information will be saved in the users table in the "Firebase" database.

Project Structure

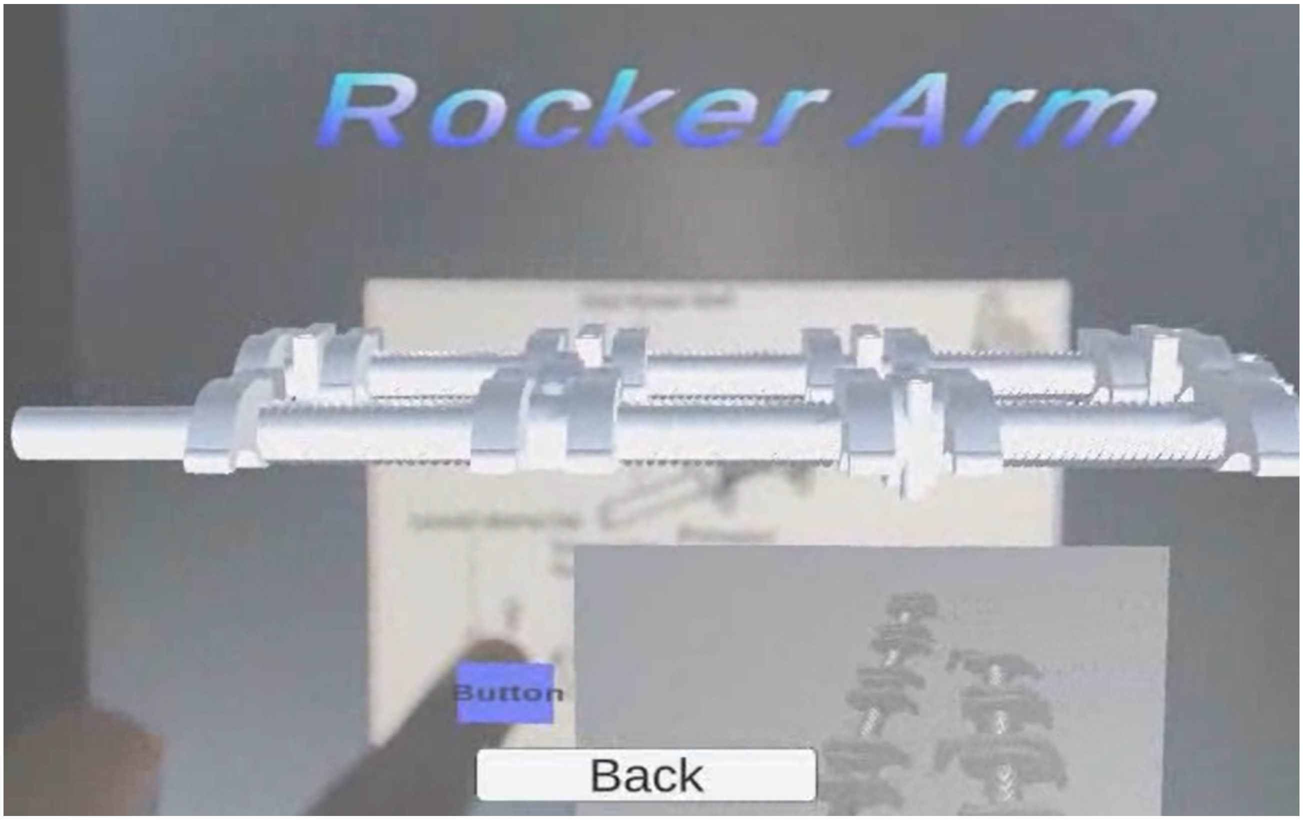

Figure 18. **Augmented Reality**

Figure 18 shows the augmented reality, where it contains the models and animations that will show the original setup of the ruins in any environment. The developer used sketch up and blender for creating the models and animations, then imported it to ARCLearning where they set target images for every model and export it to be able to implement it into Android Studio in order to make it visible to the mobile application.

Project Capabilities and Limitations

Capabilities:

- **Mobile accessibility:** Mobile learning applications with AR can be accessed on-the-go and can be used anywhere and anytime, making learning more flexible and convenient to the student.
- **Interactive and engaging:** AR can make learning more interactive and engaging, which can help the student to better understand and visualize the information about the internal combustion.

- **Real-world application:** AR can provide learners with real-world scenarios and simulations, which can help them apply their learning in a practical context.

Limitation:

- **Limited interactivity**: Mobile learning applications for internal combustion engines may have limitations in terms of interactivity due to the small screen size of mobile devices.
- **Limited processing power:** Mobile devices may have limited processing power, which can limit the complexity and depth of the content that can be included in the application.
- **Technical limitations:** AR technology requires certain technical specifications, such as camera quality, processing power, and memory, which can limit the number of devices that can run the application and affect its performance.

Project Evaluation

The proponents used ISO 9126 containing the primary characteristic, Functionality, Usability, Reliability, Maintainability, Portability, and Efficiency.

Table 16. Likert Scale

Score	Rating	Interpretation
6	5.50 - 6.00	Strongly Agree
5	4.50 - 5.00	Agree
4	3.50 - 4.49	Slightly Agree
3	2.50 - 3.49	Slightly Disagree
2	1.50 - 2.49	Disagree
1	1.0 - 1.49	Strongly Disagree

Table 16 shows the Likert Scale which is being used by the proponents to determine and measure the mobile application evaluation.

Table 17. **Evaluation Form**

Name (Optional): ____ **Date:** __________________

Sex : ________ **Student** ☐ **Professor** ☐

ARCLearning: EVALUATION FORM

Evaluation Tool: Please give your assessment of the system on the following matters by checking one of the boxes per row from one to six where one (1) is for Strongly Disagree and five (6) is for Strongly Agree

	Strongly Agree (6)	Agree (5)	Slightly Agree (4)	Slightly Disagree (3)	Disagree (2)	Strongly Disagree (1)
FUNCTIONALITY						
1. The 3D model and AR simulation working properly						
2. The application provides the topic about the internal combustion						
3. The application displays correct and accurate questions and answers.						
4. The application provides the needs of the user.						
USABILITY						
1. The application is easy to understand						
2. Application instructions are easy to follow.						
3. I felt comfortable using the application.						
RELIABILITY						
1. The application gives reliable and resourceful information.						
2. Retains overall consistency and behavior with the mobile platform.						

3. The application gives reliable and resourceful information you need.						
MAINTAINABILITY						
1. The application has a clear boundaries between the modules						
2. Are there guidelines or standards for designing new modules						
3. Are there mechanisms for testing the module separately?						
PORTABILITY						
1. The mobile app is usable by me in various android smartphone applications needed.						
2. The Application is easy to install and uninstall the mobile app from my Android smartphone.						
EFFICIENCY						
1. The response time of the application is appropriate.						
2. The application loads in around appropriate.						
3. The resources of the application are appropriate.						

Computing Standards and Modern Tools and Techniques Applied

- **Computing Standard**

The International Organization for Standardization (ISO 9126) is an international standard for the evaluation of software which has six main quality characteristics, namely: *Functionality* measures the ability of the application to serve and fulfill its essential purpose, *Reliability*: The capacity of the software product to sustain its performance level over a certain amount of time and under specified conditions, *Usability* refers to the ease of use of the mobile application to its target users, *Efficiency* is the level of performance that the software product offers in relation to the resources used under the specified parameters, *Maintainability* is the extent to which a piece of software can be altered or expanded, *Portability* focuses on the ability of application to adapt to changes on operating environments or hardware and software requirements.

- **Modern Tools**

The following tools used in developing the ARCLearning are: Android Studio for programming and creating the user interface, Adobe Photoshop for creating the logo of applications and enhancing the logo of schools, Blender 3D for creating the 3D object model of internal combustion and Firebase used to store the database online.

- **Techniques Applied**

Simultaneous Localization and Mapping (SLAMS) is an algorithm used in computer vision that allows a device to create a map of an unknown environment while simultaneously navigating and localizing itself within it.

Development Tools

3D Unity - the ARCLearning enhances the model of 3D objects that are imported in Blender 3D.

Adobe Photoshop - Adobe Photoshop used it in designing the logo of application and improved the logo of the school.

Android Studio - ARCLEarning mobile learning application was implemented by using Android Studio.

Blender 3D - Used to create the 3D Object model of the internal combustion.

Firebase - Used to authenticate the user to sign in to an application using the authentication method.

SLAM Algorithm - the ARCLEarning used the SLAM (Simultaneous Localization and Mapping) to track the environment that recognized the objects and overlay the 3D objects of the automotive parts.

Trade-offs

The ARCLearning developers created a user-friendly design so that The features of each module will be clear to the user. The programmers employed several designs and methods used to create the application. It was decided to upload the videos. To reduce the size of the application and to bring it into the present, together with the other items information to the application's users.

Multiple Constraints

Environmental – In order to function continuously, the designed program requires a stable internet connection.

Time – The mobile learning application was made using the prototyping design for the drivers to test the application to make revisions afterward. To design the application, they also have their prototype proposal used.

Technical – The project will necessitate a large amount of data in order to provide precise information and findings regarding the mobile learning application on the database.

Chapter 5

Summary, Conclusion and Recommendations

Summary of the Study

The general objectives of this study was to develop a mobile learning application that will serve as a supplemental tool for the Samson College specifically in the program of Automotive to help the students visualize about the internal combustion, and also help the professor to teach his/her student learn, This module was implemented using the Augmented Reality (AR) which is a tool that the developers used that will shows the information such as internal combustion parts and their function, In order to utilized this Augmented Reality (AR) tool the developers also made a research on how to connect the application and Augmented Reality tool to be able to shows the information of internal combustion.

Conclusion

In our project, we developed a mobile learning application designed for android phones and has a very promising potential in various areas, especially in learning critical thinking. The developers were able to utilize the SLAM algorithm for navigation logic which is applied in the application. The mobile application is evaluated using ISO 9126 which is about the software quality such as maintainability, usability, efficiency, and functionality. The mobile application gets an average of 5.37 and shows a result of respondents agreeing. Finally, the system gains 5.51 for portability that it is straightforward to install the software in a specific environment. The SLAM algorithm was used in the recommendation module of many mobile learning application genres, It is utilized in a variety of applications, including maps. The SLAM algorithm is used in a wide range of applications, such as autonomous driving mapping, and exploration.

Recommendations

Future researchers can use the study as a guide when developing another automotive-related mobile learning application. In addition, by using a different tool and including relevant modules, future researchers can enhance this application. Additionally, this study suggests additional work be done to

- Extend the scope of the Automotive Servicing Program.
    - Add more topics related to the Automotive Servicing Program.
- Enable offline to access the mobile application.
- Allow the virtual objects to overlay without a non-flat surface.

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