ABAMATU: VIRTUAL REALITY FOR TECHNICAL EDUCATION AND SKILLS DEVELOPMENT AUTHORITY AUTOMOTIVE BASIC MAINTENANCE TUTORIAL

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ABSTRACT

Virtual reality (VR) is a new computer technology that generates a simulated environment in the automotive industry. Virtual reality users can have an experience that simulates the real world of automotive and generates a 3D image. Rather than interacting with a screen, users interact with 3D reality. VR has the potential to activate multiple senses, including vision, hearing, touch, smell, and noise. To meet the requirements of both students and teachers, the researchers used technical methods to assess and gather data before deciding on descriptive as the research method for this study. This paper describes the development of the Virtual Reality for TESDA NCI Automotive Basic Maintenance Tutorial, which is a desktop and android application that allows the students to have an interactive and immersive way of learning the basic maintenance of brake and suspension system of a car. The ABAMATU application has the capability to provide the students with a new learning environment and VR makes it more engaging. On the other hand, the app still has to a lot of room for improvement, including UI, Animations, 3D models, loading speed, a forgot password feature, and extra details or directions to the scenes. Nevertheless, the application's entire functionality is operational, the designs and models are good, the development process was straightforward, and the application was able to present everything that was expected from it as well as every detail that was necessary.

Keywords

Automotive, TESDA, Maintenance, Virtual Reality (VR), Desktop Application, Android Application

1. INTRODUCTION

The proliferation of hardware and software technologies that enable the creation and manipulation of virtual representations of products and processes is a significant factor contributing to the enhancement of early problem-solving capabilities in the automotive industry. Historically, the automotive sector has been a driving force in developing and implementing modeling and simulation technologies across various industries. Advanced data management techniques and virtual technologies have significantly shortened the time required for identifying and resolving problems.

However, despite the benefits brought about by utilizing virtual modeling and simulation technology in the automotive industry, the increasing complexity of new car models and the advent of self-driving cars have presented significant challenges in efficient problem-solving. Computer-aided design (CAD) and computer-aided engineering (CAE) solutions that are traditionally desktop-based cannot address these problems. Virtual development in the automotive industry began in the early 1970s with the integration of CAD software into the design process. The first virtual reality technology demonstrations for business purposes appeared in the early 1990s, which inspired anticipation for potential business uses.

After touring the Silicon Valley and New York Virtual Reality Exhibitions in 1994, Volkswagen began comprehending the relevance of Virtual Reality (VR) and Augmented Reality. (AR). They began by investigating specific software and hardware. Regarding creating software, Prof. Encarnacao of the Fraunhofer Institute in Darmstadt was their initial collaborator. The next level required purchasing a Silicon Graphics computer and a few other pieces of hardware, such as a space mouse, data glove, and head-mounted display, even though the field of virtual reality is already well established (HMD).

Industry 4.0 emphasizes using VR and AR together since they can enhance business operations and manufacturing efficiency. The industry 4.0 process eventually forced people to adapt and increase their level of digitalization due to a few new technical hurdles. VR and AR technology is used in business, professional training (military, medical, etc.), education, simulations, model evaluation, product ergonomics research, and fast prototyping. VR and AR technology have shown to be helpful tools in the automobile sector, supporting users in process certification and product evaluation procedures. BMW began exploring and utilizing VR to assess products during the design phase in 1999.

The findings show that virtual reality technology can reduce the number of model versions needed. Motorola also created a VR training program for manufacturing line workers in 1995. The study discovered that, when compared to conventional training, VR might be used to advance one's career. Virtual reality (VR) can completely transform education by providing students with access to remarkable and immersive experiences they would not otherwise have. It can also happen in the classroom.

Virtual reality is available to all students, and teachers can supervise their use. Virtual experiences engage and inspire students in a unique way (VR, 2020). Our knowledge of the world as humans is based on the rules we have learned through experience. What we see, hear, and feel is what we believe. VR designers use basic perception principles and ideas about how people interact with the world to create experiences that feel as authentic as the actual world.

The TVL (Technical-Vocational-Livelihood) automotive track is one of the most popular among Filipino students in grades K–12. Its objective is to give graduates the abilities they need to make money without requiring them to attend college. TVL Automotive was founded in the 2016–2017 academic year. The six program strands include industrial arts, applied and specialized courses in arts and design, agricultural fisheries, home economics, information, and communications technology, applied and specialized studies in sports, and industrial arts. Even though many students chose TVL Automotive, the schools, and track ran into many problems while putting it into practice, with many of them being directly tied to a lack of resources (Miranda et al., 2021).

PROJECT CONTEXT

Building a virtual environment for the automotive industry can use two cutting-edge computing technologies: Virtual Reality (VR) and Augmented Reality (AR). Customers may receive a virtual reality simulation of the real automotive world and a 3D rendering. Customers interact with the 3D world, not a screen. According to Firu, Tapîrdea, Feier, and Drăghici (2002), VR and AR can stimulate several senses, including vision, hearing, touch, smell, and noise. The computer serves as the gatekeeper to this 3D artificial environment.

Understanding Virtual Reality is released at a time when the technologies underlying virtual reality have matured to the point where significant, productive virtual reality applications may be developed and deployed, as stated in the Morgan Kaufmann Series in Computer Graphics (2003). This comprehensive, user-friendly assessment aims to help you capitalize on this opportunity by providing you with the knowledge you need to recognize and plan for ways VR can be used in your area. The writers have built a resource that will be useful even when the underlying technology change. You get a history of VR and an honest look at modern systems. The emphasis, however, remains squarely on the use of VR and the numerous difficulties in application design and execution, including hardware requirements, system integration, interaction strategies, and usability.

CONCEPTUAL FRAMEWORK

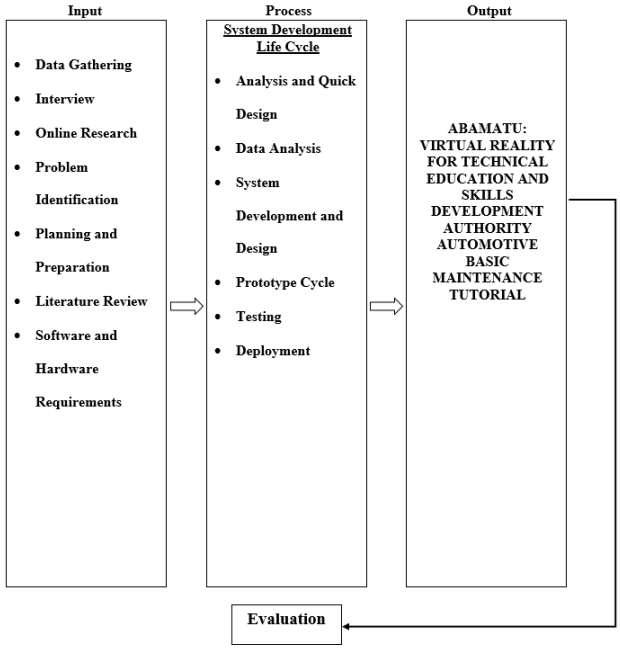

Figure 1: Conceptual Framework

The input, process, and output framework for the Virtual Reality for NC I Automotive Basic Maintenance Tutorial is shown in Figure 1. The researchers offered pertinent papers and literature to develop the project's conceptual framework.

OBJECTIVES OF THE STUDY

The general objectives of ABAMATU: Virtual Reality for Technical Education and Skills Development Authority Automotive Basic Maintenance Tutorial are specified in the following:

1. To design a 3D model of brake and suspension system components that would provide students with a realistic experience.
2. To develop a system that uses virtual reality to simulate basic brake and suspension system maintenance.
3. To provide NCI Automotive Servicing Students with an immersive and dynamic learning environment.
4. To perform an assessment to test the students' learnings and progress.
5. To evaluate the ISO 25010 software quality model using the following criteria:
    a. Functionality
    b. Performance Efficiency
    c. Compatibility
    d. Reliability
    e. Security
    f. Maintainability
    g. Portability

SCOPES AND DELIMINATIONS

The Virtual Reality for NC I Automotive Basic Maintenance Tutorial is only usable for NC I Automotive Servicing students. The design focuses on developing the Virtual Reality Automotive Basic Maintenance Tutorial System that will automate the essential maintenance of a car's brake and suspension system. The system aims to provide efficient, specific, reliable, and accurate information for the students to have a stable and efficient learning platform for essential maintenance (brake & suspension system). The system is accessible for Technical Education and Skills Development (TESDA) NC I Automotive students on Android and desktop computers. The system cannot be used offline. Access to the system is restricted to authorized users and NC I Automotive students from Technical Education and Skills Development (TESDA). The data and information gathered during virtual reality training are not accessible to the public.

SIGNIFICANCE OF THE STUDY

The following will be necessary to the proposed system, which is called "ABAMATU: Virtual Reality for TESDA Authority Automotive Basic Maintenance Tutorial":

Students: This research will benefit students by educating them on automobile brake and suspension systems' fundamental upkeep.

Teachers: The teachers will benefit from this application since it will allow them to train their students how to perform essential maintenance on a car's brake and suspension systems.

Future Researcher: This research will also aid future researchers in making research more efficient. Future scholars can use this study if individuals ever wish to build a system similar to this proposed one. This project will serve as a model for colleagues. In addition, if other issues occur, the developers hope that future academics will fix them using the data acquired.

DEFINITION OF TERMS

The functional definitions of the terminology mentioned below were gathered and utilized for the system's construction. Terms and definitions are as follows:

Virtual reality - is an environment created by a computer that immerses the viewer in their surroundings by displaying realistic-looking objects and situations.

Automobiles - are created, used, produced, or sold in the automotive industry:

TESDA - The Technical Education and Skills Development Agency (TESDA), a government agency, directs and supervises technical education and skills development in the Philippines (TESDA).

Braking system - a configuration of brake lines or mechanical connections of various linkages and parts, such as master cylinders or fulcrums. So forth, that transfers the kinetic energy of the vehicle.

A protective lattice made up of dampers and springs that absorb stress is known as a suspension system.

Tech-savvy refers to someone knowledgeable about or skilled at using modern technology, particularly computers.

Stereoscopic - is a term used to refer to or describe a method whereby two images of the same object obtained from slightly different angles are merged to provide the impression of depth and solidity.

Implementation- is the process of putting a decision or plan into action; execution.

Augmented- having been made more significant in size or value.

2. METHODOLOGY

RESEARCH DESIGN

A descriptive study aims to provide a clear and systematic picture of a specific group, situation, or phenomenon. The study will investigate questions such as "what," "where," "when," and "how" by using the method of descriptive research to gather and analyze data. This will allow the researchers to determine the significance of their findings and evaluate the level of understanding automotive students gained through the system under examination.

RESEARCH INSTRUMENT

The primary means used by the researchers to acquire the necessary data was a survey questionnaire. This questionnaire was composed of a set of predetermined questions about a specific topic, providing space for the respondents to answer each question. As part of their study on "ABAMATU: Virtual Reality for TESDA Automotive Basic Maintenance Tutorial," the researchers used both questionnaires and interviews to gather the needed information.

INTERVIEW

The researchers conducted interviews as a means of obtaining more reliable data. By visiting various training centers, the researchers gathered factual information, which they then used to identify the most efficacious methods of recruiting participants for the study.

QUESTIONNAIRES

A survey questionnaire was the primary tool the researchers used to gather the required data. This survey was composed of several uniform questions, or items, that were organized in a preset way to gather specific information on one or more predetermined themes. In order to get comments and suggestions from the respondents about potential changes to the application, the researchers also used questionnaires.

ONLINE RESEARCH

The researchers used the internet to collect data online in a more dependable, effective, and efficient way. They were able to obtain and evaluate data using various internet platforms, including email and texting. Online data collection gathers information using digital communication channels, including emails, text messages, and other digital communication methods. This approach gives participants plenty of time to answer the survey or questionnaire, which produces more reliable data.

EVALUATION INSTRUMENT OR CRITERIA

The ISO 25010 Software Quality Characteristics will be used in the ABAMATU: Virtual Reality for TESDA Automotive Basic Maintenance Tutorial. The ISO 25010 Software Quality Model identifies characteristics, Functionality, Reliability, Usability, Efficiency, and Portability.

Functionality – The required functions available in the software that satisfies users' satisfaction.

Efficiency – It is focused on evaluating the inputs with the outputs and finding how to maximize results considering the resources allocated effectively.

Usability – This feature determines how simple an interface design is to be used.

Reliability – Characteristics that relate to a software's capacity to sustain its performance requirements under specific circumstances for a predetermined amount of time.

Portability - is the process of moving a system, product, or aspect from one device, application, or other operations, maintenance, or usage environment to another.

STATISTICAL PROCEDURES

The proponents retrieved the surveys and then utilized statistical analysis to determine the optimal interpretation. Weighted mean was used to gauge the relative relevance of the factors under consideration using the formula below.

Weighted Mean

$$WM = \frac{\sum \mathbf{WV}}{N}$$

Where:

WM = Weighted Mean

WV = Weighted Value

$\sum$ = Symbol for the summation process

N = Number of respondents

Table 1: The following rating scales and related values were used in the survey to determine if the respondents find the system useful.

Rating Scale	Descriptive Rating
4	Strongly Agree
3	Agree
2	Disagree
1	Strongly Disagree

Table 1.1: Likert Scale

Weighted Mean	Descriptive Rating
3.26 – 4.00	Strongly Functional
2.51 – 3.25	Functiontal
1.76 – 2.50	Not Functional
1.00 – 1.75	Strongly Not Functional

SYSTEM DEVELOPMENT METHODOLOGY DESIGN

The proponents chose the Agile Methodology because it suits their application development strategy. In contrast to traditional app development methods, agile does not test the app after it is developed. Instead, it emphasizes simple module testing. This reduces the likelihood of encountering a bug while quality testing the complete product and making necessary changes. The premise behind agile Methodology is that the successive stages' cycles focus on improving product quality with customer feedback.

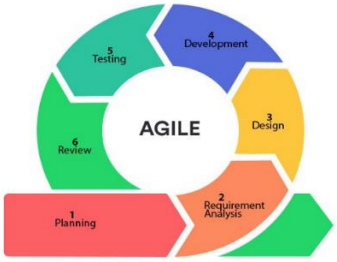

Figure 2: Agile Methodology

PLANNING

Agile planning is interactive. This implies that you create and adjust your plan as frequently as necessary. Planning ahead of time and promptly adapting to changes that occur during the execution phase are essential goals. Proponents begin by studying and determining the problem. Once the problem has been identified, and one or more solutions have been chosen, the process of putting the solution into action begins. The proponents learned about the challenges with the current system and assisted in identifying the students' needs and specifications.

REQUIREMENTS ANALYSIS

During the project life cycle, requirements may change in agile development. The faster the program is released, the faster it can respond to changes in learning modules, new technologies, or changing educational needs. Potential alternatives were developed after identifying the problems with the current system and obtaining data, records, and other related documentation.

DESIGN

The phases of an agile system design are continuous. After breaking it down into distinct components that may be delivered, you begin working on the functionality. As a result, you can design more swiftly and receive feedback on your work more quickly. The conceptually proposed application was created due to system development, then transformed into a physical application design. The proposed system's programming language, hardware, and software platforms are also selected at this phase.

DEVELOPMENT

A collaborative process of self-organizing and cross-functional delivery, quality improvement, and adaptable responses to changes in demand, capacity, and understanding of the challenges to be addressed is used to carry out specification discovery and master planning in software design using agile methodologies. The supporters are presently coding according to the standards and design chosen in earlier phases. To finish the application and meet the standards, work has already begun on the user interfaces and actual programming.

TESTING

Continuous communication between developers, customers, managers, stakeholders, and testers is critical for Agile testing. Testing is an essential component of the development process. This testing method focuses on the application function rather than the design. The standard and actual findings were compared to ensure that the system works properly. The test is built on the requirements and functionality.

REVIEW

With this step, the agile development cycle is complete. After completing all prior stages of development, the development team informs the owner of the results obtained in fulfilling the requirements. Following that, either a fresh iteration or moving on to the next phase and scaling Agile will restart the phases of Agile software development.

UNIT TESTING

Unit test plans were made while the module configuration phase was in progress. These unit test plans were executed to eliminate errors at the code or unit level.

To determine whether the application was accurate based on what was reported during the requirement analysis phase, the proponents sought to find errors and problems inside the system. The product might be prepared for distribution after testing to remove any faults like bugs.

INTEGRATION TESTING

Integration testing was performed following the completion of unit testing. The system was examined, and the components were coordinated during incorporation testing. The Architecture configuration stage underwent integration testing. This test validates the relationship between the components.

The proponent tested each piece of code and software to see if it interacted adequately and to look for interface issues. After doing integration testing on the features, proponents went on to system testing.

SYSTEM TESTING

System testing examined the entire application for usefulness, reliability, and correspondence. It tested both the helpful and ineffective prerequisites of the built application.

The proponents and testers examined the system's functionality to see if it could match the requirements. For advancement checking, the system ran a variety of tests.

ACCEPTABILITY TESTING

During the beta testing phase, the assigned users or clients will now execute a real-world test on the application. It will allow them to explore the system's capabilities and select from predetermined categories.

ORGANIZATION ASSESSMENT OF SUBJECTS

TECHNICAL FEASIBILITY

The study's authors must demonstrate that they have the necessary internal resources to accomplish the project. Based on the technologies used to construct the proposed system, it will be evident whether or not the project is technically feasible. This is done to ensure that the advocates continue to perform successfully after the program has been developed, tested, and saved. The properties of the suggested system will reflect how functional the system is.

OPERATIONAL FEASIBILITY

The system's proponents must assess the area's operational viability to meet users' expectations. This analysis' findings will be of higher quality and more efficient. Following the development, the system will have a higher success rate in terms of operational viability. Proponents of the system thoroughly evaluated it by testing, observing, and giving comments. The information acquired from the region would assist the proponents in meeting the end users' expectations.

FINANCIAL FEASIBILITY

The system's proponents invested time and resources in developing it. They also spend money on printing and time traveling to the research site to submit the required paper for the study. Its financial viability will thus determine the system's benefits. The principal benefits must outweigh the costs of developing and implementing the system. Users will benefit from it more than it costs to generate because it is inexpensive to produce, and anybody can build a system using instructions and the internet.

RESPONDENTS OF THE STUDY

The proponents pursue three (3) IT professionals to provide suggestions and recommendations on developing the proposed ABAMATU: Virtual reality for TESDA automotive basic maintenance tutorial. They will be the Alpha Testers for the proposed system. At the same time, the proponents selected forty-nine (49) current NCI TESDA Automotive Servicing Students from Pampanga Manpower Training Center (PMTC) as Beta Testers for the study.

Context Flow Diagram of the Proposed System

The context flow diagram of the proposed system may be found in Appendix A. The context flow diagram of a vision document is a simple visual that displays the source systems that supply data to a DW/BI system and the primary user constituents and downstream information systems it supports (Hughes, 2016).

Data Flow Diagram of the Proposed System

A Data Flow Diagram (DFD) is a graphical representation of how data goes through an information system, and it may be found in Appendix B for the proposed system. It gives a visual picture of the functionality of the information system, its process, and when and how improvements will be made.

Entity-Relationship Diagram of the Proposed System

An entity-relationship diagram (ERD) is a type of data presentation showing the relationships between the objects or concepts in a data system or association graphically. ERDs are used to define data set coherence and can be found in Appendix C for the proposed system.

System Process Flowchart of the Proposed System

The System Process Flowchart of the proposed system can be found in Appendix D. The users need to log in. If the user data are valid, they can go to the main menu and play/explore the application; if the user login info is invalid or not registered, they can go to the registration panel and register a valid email.

System Design of the Proposed System

The proponents created a nice design to make the user interface more pleasing to the users' and kids' eyes. To make the system more user-friendly, the supporters shortened the procedure. Appendix E contains screenshots of the system design.

Requirements Analysis and Specification

Table 2: Hardware

Laptop	
Components	**Specification**
Processor	Intel® Core™ i5-13600KF Processor
RAM	8GB
Storages	1TB of HDD storage
Graphic Card	GTX 1650
Mouse	USB
Camera	720p HD
Router	25mbps speed of a network
Smartphone	
Components	Specification
Processor	Qualcomm Snapdragon 845, Kirin 810 and better
RAM	4GB
Storage	8GB
Display	Strictly 1920x1080
OS	Android 8.1 and above

Table 2.1: Software

Laptop	**Smartphone**
Windows 10	Android 8.1 and above
C# and php	Qualcomm Snapdragon 845, Kirin 810 and better
Unity 3D 2021.3.4f1	4GB
VS 2019	

TEST OR EVALUATION PLAN

IMPLEMENTATION PLAN

The system was constructed using the data from the earlier stages. Once it was finished, the proponents had to do a test to make sure it was accurate and functioning. During testing and system operation, the improvements were maintained.

3. RESULT AND DISCUSSION

This chapter provides examples of the analysis, presentation, and interpretation of the data. The results are shown graphically and in tabular format.

A carefully chosen set of respondents was given questionnaires to complete in order to assess the functional adequacy, performance efficiency, compatibility, usability, dependability, and security of the current system.

The study's respondents, who were chosen using a purposive sampling technique, consist of 39 NCI Automotive Servicing students from the Pampanga Manpower Training Center and three (3) IT professionals.

Tables and Figures (ALPHA)

The tables presented below show the survey result and the opinions of the I.T experts about the system.

Table 3: Alpha Testers of the study

I.T EXPERTS	NO. OF RESPONDENTS
I.T Experts	3
TOTAL	3

Table 3 shows the total Alpha testers of the study consisting of three (3) I.T experts that will test and give insights and recommendations on the proposed system.

Table 3.1: Summary of the Alpha Test Results

Criteria	**WM**	**Descriptive Rating**
Performance Efficiency	3.78	Strongly Functional
Usability	3.22	Functional
Portability	3.78	Strongly Functional
Reliability	3.78	Strongly Functional
Functionality	3.58	Strongly Functional
Security	4	Strongly Functional
Average Weighted Mean	**3.69**	**Strongly Functional**

Table 3.1 shows the frequency distributions, weighted mean, and the descriptive ratings of the I.T experts in the Security of the system.

The total weighted mean for the overall criteria is 3.69 and has a descriptive rating of strongly functional. It means that the application, based from the I.T experts in overall criteria, was Strongly Functional.

Tables and Figures (BETA)

The tables presented below show the survey result of the Respondents about the system

Table 4: Respondents of the study

REPONDENTS	**NO. OF RESPONDENTS**
Respondents of NCI Automotive Servicing Students of Pampanga Manpower Training Center	49
TOTAL	49

Table 4 shows the total respondents of the study consisting of forty-nine (49) PMTC students that will be the beta testers for the study.

Table 4.1: Summary of the Beta Test Results

Criteria	WM	Descriptive Rating
Performance Efficiency	3.54	Strongly Functional
Usability	3.49	Strongly Functional
Portability	3.53	Strongly Functional
Reliability	3.56	Strongly Functional
Functionality	3.56	Strongly Functional
Security	3.54	Strongly Functional
Average Weighted Mean	**3.53**	**Strongly Functional**

Table 4.1 shows the frequency distributions, weighted mean, and the descriptive ratings of the Respondents in the overall criteria of the system.

The total weighted mean for the overall criteria is 3.53 and has a descriptive rating of strongly functional. It means that the application, based from the Respondents in overall criteria, was Strongly Functional.

Table 5: Overall assessment of the Respondents of the System

Criteria	ALPHA	BETA	WM	Descriptive Rating
Performance Efficiency	3.78	3.54	3.66	Strongly Functional
Usability	3.22	3.49	3.36	Strongly Functional
Portability	3.78	3.53	3.65	Strongly Functional
Reliability	3.78	3.56	3.67	Strongly Functional
Functionality	3.58	3.56	3.57	Strongly Functional
Security	4	3.51	3.76	Strongly Functional
Grand Mean = 3.61 Strongly Functional				

Table 5 shows the overall assessment, weighted mean, and descriptive ratings of the respondents in the overall evaluation of the system.

Overall, the system grand mean is 3.61 and has a descriptive rating of a Strongly Functional. In terms of Performance Efficiency, Usability, Portability, Reliability, Functionality, and Security, the system passed based on the evaluation of Alpha and Beta testers

4. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The application was successfully developed, and everything proceeded as planned: all functionalities were completed, designs and models were good, and the development process was smooth. The application was able to show everything that was expected and every detail that was necessary for it.

It is safe to state that objectives were met because the application's creators did an excellent job of building it and because it earned surprisingly high marks from the respondents. Thanks to an IT specialist's analysis, the process and demonstration goals were also met. The assessors were divided into categories based on the respondents' availabilities. Through a VR-based scenario game, the application teaches users about garage surroundings and fundamental brake and suspension system maintenance.

RECOMMENDATIONS

Regarding the findings and conclusions made on this study by the proponents, the following are recommended for future developers interested in improving the application.

1. Enhance the application's user interface to increase its usability and appeal, attracting a more extensive user base. Additionally, consider implementing a specific theme for the game's user interface to improve the user experience further.

2. Improve the animation of maintenance procedures and increase the realism of the 3D models for a more immersive user experience.

3. Enhance the application's scene-loading capabilities for a smoother user experience.

4. Implement a feature that allows users to reset their passwords if they have forgotten their account login credentials.

5. Include additional information or instructions within the game's scenes, particularly during the initial launch, to guide users on their actions or content available within the game.

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5. ACKNOWLEDGMENTS

Above all, deepest gratitude is offered to God for the blessings, guidance, knowledge, wisdom, and strength throughout our research journey. The students are truly grateful for the support and guidance provided by the Almighty during the difficult times faced while completing this research.

Heartfelt appreciation is extended to the research adviser, Mr. Evicen C. Flores, who has been an invaluable source of knowledge and support throughout this research journey.

To the alpha testers, Mr. Manjares Domingo, Mr. Aleczis Bautista, and Mr. Eduardo Rafael, who has played a vital role in the development and success of this research, their invaluable feedback and constructive critiques have helped to improve the research paper and make it more valuable to the audience.

To the research instructor, Mr. Lionel De Lazo, who provided the students with the knowledge, skills, and resources needed to complete this research.

To the research panelists, Mr. John Bernard Tungol, Mr. Earl Lawrence Pelayo, and the Chairman of this research, Mr. Reden Paul Rivera, who have provided valuable insights and perspectives on our research. Y

Lastly, to their family members and friends, who have supported us through every step of our research journey. Their unwavering support and encouragement have been invaluable. This humble accomplishment will not be possible without them.

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