Accelerating Automotive Education in the Digital Age through Virtual training Platform for Vehicle Anatomy

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ABSTRACT

Nowadays, the automobile companies, like many other industries, are dealing with a new digital workforce and environment. In today's technology, a computer controls or monitors almost every component of a contemporary car. Due to this scenario, various instructional materials are employed to educate vehicle service and repair, including hands-on workshop activities towards understanding the vehicle. Accordingly, virtual training material was developed as an immersive virtual teaching and learning strategy for vehicle anatomy, focused on automotive technicians of the Automotive Systems Engineering academic program, as a practical teaching-learning tool in Education 5.0. This teaching material will help trainees at car companies not only in the aspect of vehicle servicing but also in the design of new vehicles.

INTRODUCTION

Education and training are becoming increasingly important for learning new skills in many different areas, particularly assembly and disassembly (Lai et al., 2002). Like many other industries, the automotive industry faces a new digital workforce and environment. An electrical circuit or computer module controls or monitors every part of a modern automobile. When these systems break down, automotive technicians need solid skills to quickly and efficiently determine what component is causing a fault and repair the automobile properly. Learning to diagnose electrical faults efficiently can be challenging because many automotive students feel that electrical diagnosis is complicated and beyond their abilities (Lai et al., 2002). Additionally, it is much easier to observe how the mechanical parts of an automobile fit and work together to accomplish a purpose than it is to see how the electrons work in an electrical circuit or a computer module to accomplish a purpose. Due to the importance of electrical troubleshooting skills and some students' difficulty developing these skills, educational tools and approaches to help students are needed.

Towards this scenario, many teaching tools are used to teach automotive service and repair. These range from traditional academic lectures and textbooks to hands-on shop work and computer-based resources (Gong, 2021). Implementing age-friendly work practices and providing targeted training programs can help ensure the safety and well-being of older workers (Bakkiyaraj et al., 2020; Win et al.,2021; Winkes & Aurich, 2015). Therefore, students must train to be automotive technicians and acquire a solid foundation in electrical troubleshooting to succeed in the automotive repair industry. Each teaching approach is unique. However, if adequately developed, a computer-based diagnostic troubleshooting simulator could be a very effective learning tool for accomplishing this goal. Ensuring proper training and implementing mechanical aids can mitigate these risks, but they often require significant investment and adaptation of existing processes. Thus, this study aims to produce a user-friendly training systems module (e-educational modules) for automotive vehicle structures.

LITERATURE REVIEW

Tables Features of Knowledge Transfer in Modern Conditions of Digital Transformation

Knowledge encompasses a range of models, methods, and techniques tailored to develop systems intended for problem-solving purposes. It constitutes a theory, methodology, and technology encompassing various approaches to extracting, analyzing, presenting, and processing expert knowledge. In this context, knowledge denotes a collection of information, concepts, and ideas acquired through teaching, experience, life's journey, and other means typically applied in practical activities. At a broad level, the knowledge process comprises three key stages, as illustrated in Figure 1. These stages involve (1) Extracting Natural Knowledge, which involves transforming "raw knowledge" into structured knowledge; (2) Implementing Structural Knowledge, which is the process of incorporating organized knowledge; and (3) Operationalizing Knowledge, wherein structured knowledge is transformed into practical operational knowledge.

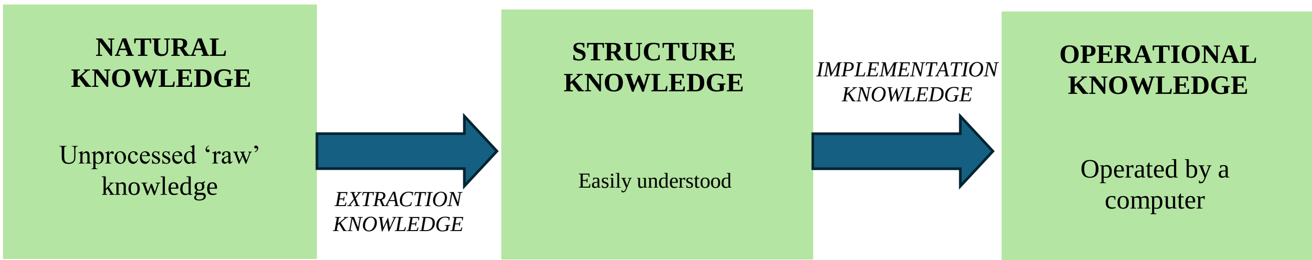

Fig. 1 Process of knowledge

The essence of the knowledge transfer concept within education lies in fostering the acquisition and refinement of students' capability to apply conceptual understanding and procedural skills in real-world professional scenarios (Roopa et al., 2021). To facilitate this, diverse tools and models have been developed to manage knowledge and its representation efficiently, aiming to realize this overarching objective. Consequently, an in-depth examination by Burke and Hutchins (2007) delves into the primary factors impacting knowledge transfer, including the attributes of the learner, the design and execution of interventions, and the influence of the working environment.

METHODOLOGY

As described above, this research focused on developing a Virtual Reality Lab for teaching and training in Automotive Systems Engineering by focusing on Vehicle Structure. This innovative solution for automotive safety and health environment was developed based on theory-based models for teaching problem solving: the **R2D2 Model** by Bonk and Zhang (2006). This theory corresponds with a constructivist learning viewpoint, as the model emphasizes what the students can do rather than a sequence of steps the instructor should do. The theory integrates four learning activities: Reading, Reflecting, Displaying, and Doing. The R2D2 model provides a framework for more engaging, dynamic, and responsive teaching and learning in online environments. For the development of the online environment, the following requirements and operation modes were established:

Table 1 Established R2D2 Model requirements and operation modes

No	Learning Activities	Description
1.	**R**eading	Learners obtain knowledge through online readings and listening to virtual explorations.

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2.	**R**eflecting	Reflective activities such as self-check examinations
3.	**D**isplaying	Virtual Tours, Timelines, Animations, And Concept Maps
4.	**D**oing	Hands-On Activities Including Simulations, Scenarios, And Real-Time Cases.

Design Development

As a first step for developing the application, the main scenario was built, which consisted of recreating a virtual analogue of the real teaching laboratory. To create the main scenario, the Pixma Software was used with the corresponding plugins to generate an environment in Virtual Reality. The design development process begins with course mapping based on the course goals and learning objectives, as well as supporting learning materials that are engaging and formative and summative course assessments. For these pilot projects, 6 lesson topics under the Vehicles Structure module will be developed. The course mapping is shown in Figure 2 below.

Fig. 2 The Course Mapping

Section Course mapping is essential to designing this virtual environment lab to ensure the course is well structured and will equip students to meet learning goals. Traditionally, course design and development start at the beginning of the course content and progress to the end. After completing the course mapping, the process continues with the interface design development. The company's corporate color was chosen as a fundamental outlook for the whole concept. User Interface (UI) refers to the visual part of the course that users interact with. The user interface encompasses menus, navigation buttons, and page (or slide) layouts. Figure 3 illustrates the user interface for the introduction lesson topic, while Figure 4 displays the content page.

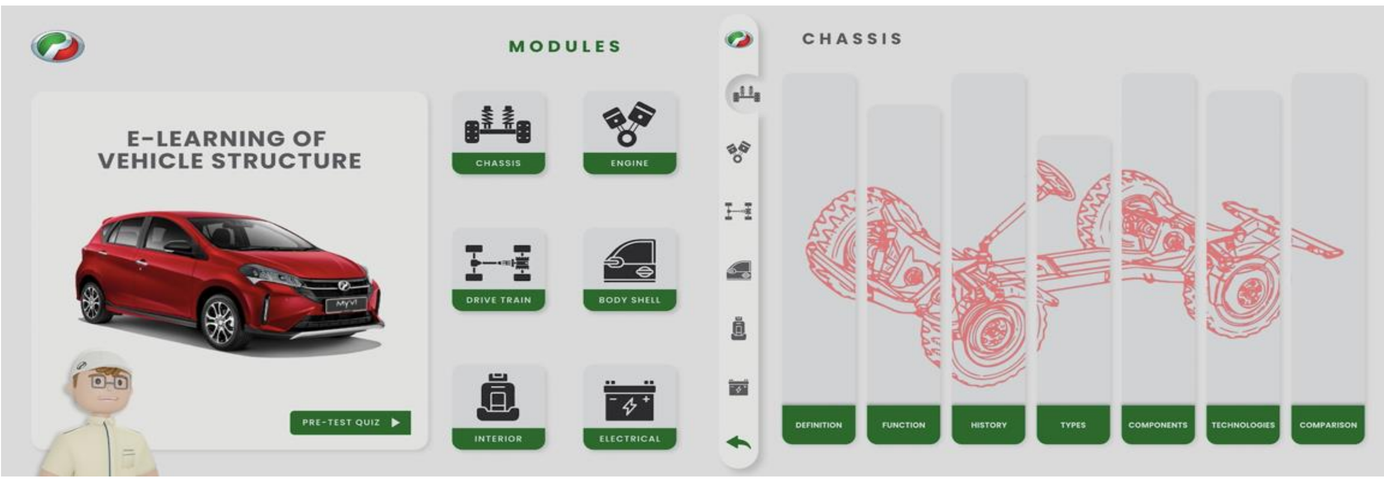

Fig. 3 The front page and example of introduction page for one of the lesson topics.

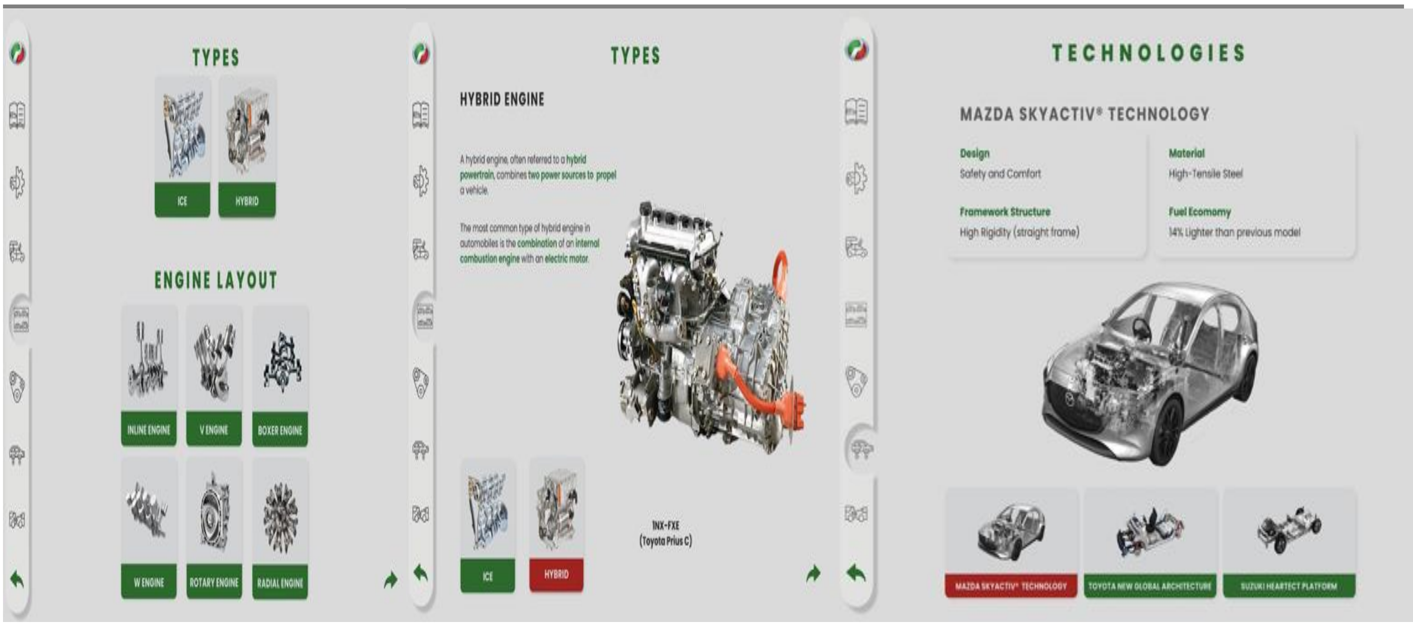

Fig. 4 The example of content page

This virtual environment lab also contained a simulation. In the context of online automotive education, simulation refers to simulating real-world automotive systems, procedures, and settings using virtual models and situations. These simulations can include simple interactive graphics or intricate, lifelike landscapes that replicate actual driving circumstances, car attitudes, and engineering difficulties. Figure 5 shows an example of a simulation page.

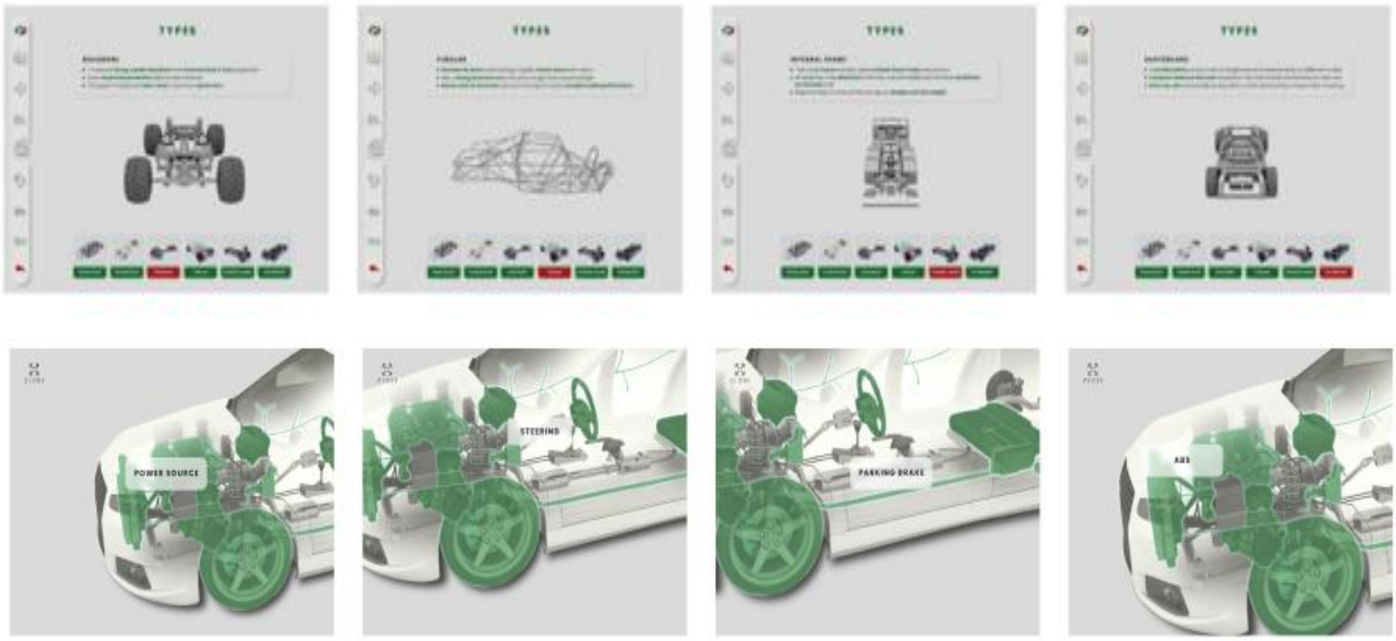

Fig. 5 The example of simulation page

The simulations provided in this virtual environment lab enhance understanding and practical skills by replicating real-world automotive systems and scenarios in a virtual environment. Additionally, it allows learners to experiment, practice, and make decisions safely and cost-effectively, providing immediate feedback and engaging interactive experiences. This approach also helps visualize complex concepts, develop hands-on skills without physical risks, and efficiently scale training programs, all while keeping content current and relevant. In this virtual environment lab for automotive online learning, the course assessments page is critical for evaluating learners' understanding and skills in a simulated setting. Figure 6 is an example of components included in the assessments page.

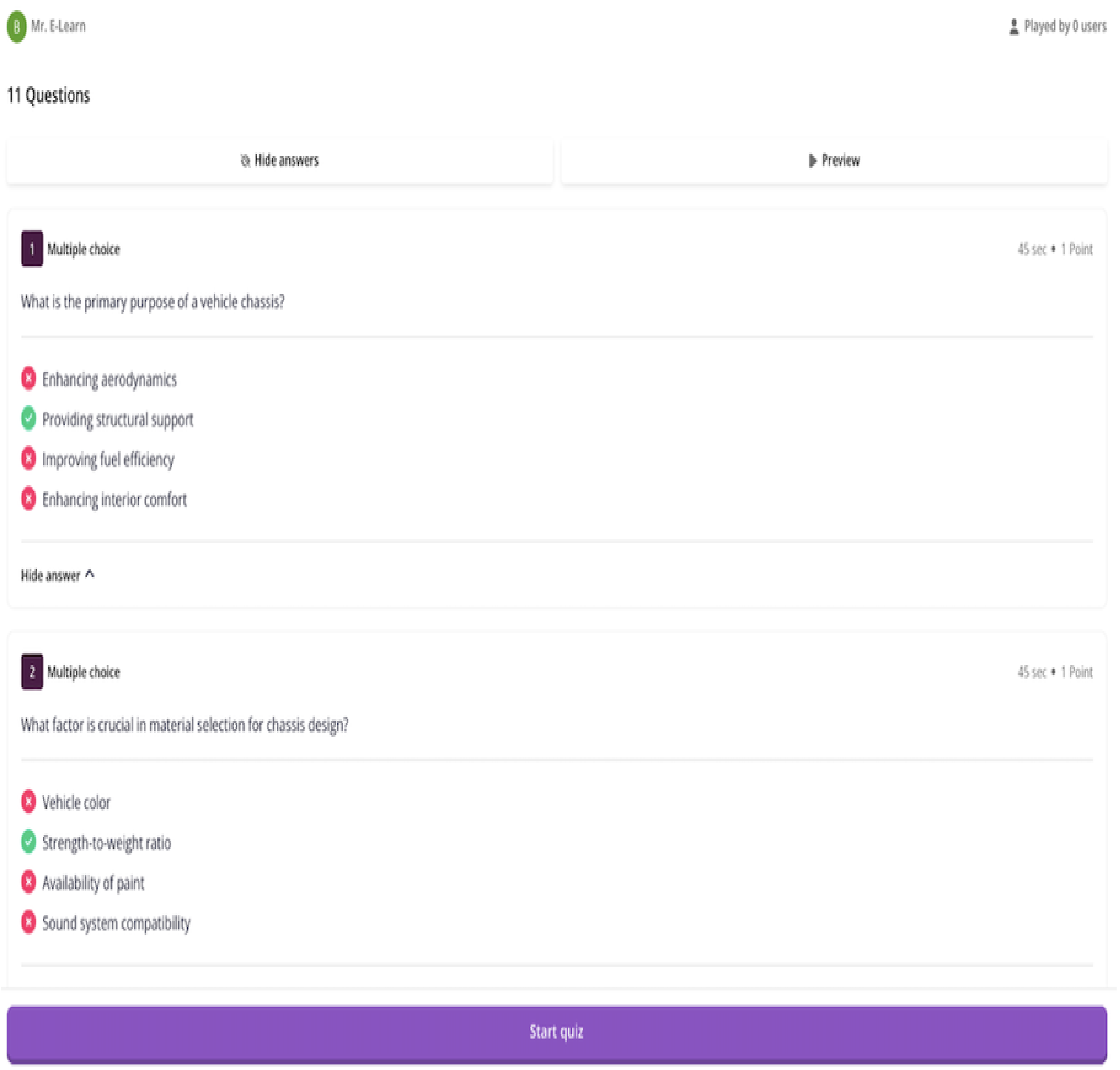

Fig. 6 The example of course assessments page

The components of an assessment page in a virtual automotive online learning environment typically include assessment types (quizzes, practical simulations, and case studies to evaluate both knowledge and hands-on skills), performance metrics (test scores and progress tracking to monitor learner achievements and areas for improvement), submission and review (options for submitting work and receiving instructor feedback) and certification and badges (digital recognition for completed assessments or mastered skills). This comprehensive approach ensures that learners are assessed thoroughly across theoretical knowledge and practical skills in the virtual automotive environment. In summary, the assessment page in a virtual automotive online learning environment integrates diverse components to evaluate theoretical knowledge and practical skills comprehensively. Moreover, support resources and discussion forums foster continuous learning and problem-solving, making the assessment page vital for effective and engaging automotive education.

CONCLUSION

Using the R2D2 model was straightforward due to its easy-to-follow format. The model matched the tutor's philosophical approach to design, where students actively engage in learning activities that meet their needs for understanding and using automotive vocabulary in real-life contexts. The model emphasizes a learning process that places the student at the center of the design process, enabling them to be engaged in the active processes of reading, reflecting, displaying, and doing. A strength of the model is that it magnifies two phases – reflection and doing, which are often overlooked in blended environments.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the paper's publication.

Author Contribution

The authors confirm their contribution to the paper as follows: **study conception and design:** Author NK, Author AA, Author HR, Author MHJ; **data collection:** Author NK, Author AA, Author HR, Author MHJ; **analysis and interpretation of results:** Author NK, Author AA, Author HR, Author MHJ; **draft manuscript preparation:** Author NK, Author AA, Author HR, Author MHJ; All authors reviewed the results and approved the final version of the manuscript.

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