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Wonder Table: An Android Based Augmented Reality Learning Tool for Periodic Elements

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COMPUTER EDUCATION DEPARTMENT

Abstract:
The periodic table is a fundamental component of chemistry education, yet many students struggle to grasp the abstract concepts and relationships among chemical elements when using traditional teaching methods. To address these learning gaps, this study introduces Wonder Table, an Android-based Augmented Reality (AR) learning tool designed to improve visualization, engagement, and comprehension of periodic elements by allowing users to scan printed markers that instantly generate interactive 3D models, animated representations, and concise element information, transforming static learning materials into immersive digital experiences. To evaluate the system's effectiveness, the researchers conducted surveys. They administered both traditional and AR-based quizzes among elementary and high school students at Butuan Christian Community School and college students at Caraga State University, selected at random. Results revealed that students scored 22–30% higher on AR-assisted quizzes than on traditional quizzes. At the same time, survey data showed that 87% of respondents reported increased interest, 81% noted improved understanding, and 79% experienced greater motivation to study chemistry when using the tool. Beyond academic performance, students showed increased curiosity, confidence, and enjoyment, and teachers observed enhanced participation, collaboration, and more precise visualization of complex concepts. Overall, Wonder Table demonstrates that integrating augmented reality into science education significantly improves learning outcomes, strengthens engagement, and modernizes the teaching process. The study recommends expanding the AR content to include additional chemistry topics, integrating gamified assessments, and adopting AR technologies more widely across educational settings.

Keyword: Augmented Reality, Periodic Table, Chemistry Education, Mobile Learning, Interactive Learning Tool, Student Performance, 3D Visualization, Learning Outcomes.

INTRODUCTION

1.1 Rationale of the Study

Chemistry is often regarded as one of the most challenging science subjects due to its abstract concepts, symbolic notations, and reliance on three distinct levels of representation: macroscopic, submicroscopic (atomic/molecular), and symbolic, all of which can be difficult for students to visualize and connect (Rahmawati et al., 2022). Topics such as atomic composition, bonding, and periodic trends are challenging to grasp when taught solely through traditional methods, such as textbooks, lectures, and static illustrations (Ribič et al., 2025). As a result, many students rely on rote memorization of the periodic table, which may support short-term recall but often fails to promote deeper understanding and long-term retention (Byusa et al., 2022; Ugorji et al., 2023).

Augmented Reality (AR) offers a powerful solution to these challenges by providing interactive, hands-on learning experiences (Son et al., 2025). AR overlays digital information, such as 3D models, onto the real world, allowing students to engage directly with complex scientific content. Studies have shown that AR not only boosts motivation and interest but also improves comprehension and memory, especially in STEM subjects (Alanzi et al., 2023; Alghamdi et al., 2025). Additionally, AR supports different learning styles and encourages exploration through visual and physical interaction (Smith et al., 2023; Liu et al., 2024).

To meet the growing need for innovative educational tools, this study introduces Wonder Table, an Android-based augmented reality learning tool for periodic elements. This app allows users to scan their surroundings and interact with 3D periodic elements using their mobile devices. It also includes built-in quizzes to reinforce learning and test student understanding. By combining AR technology and interactive features, Wonder Table aims to make chemistry more accessible, engaging, and effective. Backed by recent research and educational innovations (RMIT University, 2024; Urzúa Reyes, 2021), this project advances student-centered learning in science education.

1.2 Project Concept

The Wonder Table application is designed to transform how students explore and understand the periodic table through Augmented Reality (AR). Using the device's camera, the app projects interactive 3D models of elements, which users can tap to view detailed information such as atomic number, atomic mass, electron configuration, and discovery background. To reinforce learning, the application integrates quizzes that allow learners to test and review their knowledge.

The system is developed in Unity and uses the Vuforia Engine to enable marker-based AR experiences, including object recognition, tracking, and visualization. To create realistic, detailed 3D models and animations of periodic elements, the researchers used Blender, a 3D modeling and animation software. Additional visual assets were refined using Adobe Photoshop and Adobe Illustrator, while C# scripting within the Unity environment manages app functionality, interactivity, and quiz logic.

By combining interactive technology with advanced 3D modeling, Wonder Table provides a user-friendly, visually engaging, and pedagogically effective platform. It is designed not only for students but also for science enthusiasts who want to explore the periodic table in an immersive and meaningful way.

1.3 Purpose and Description

The purpose of this study is to design, develop, and evaluate an Android-based Augmented Reality application that enhances learning of the periodic table. Traditional teaching methods often emphasize memorization, which many students find tedious and ineffective. By contrast, AR provides opportunities to interact with 3D models, making scientific concepts more concrete, engaging, and memorable.

The application also includes quizzes to assess understanding and encourage active participation. To effectively reinforce learning, these built-in quizzes will use a combination of Multiple-Choice Question (MCQ) formats. The questions are designed to test the learner's comprehension and recall of key data presented in the AR models, including atomic properties and electron configurations.

To evaluate its effectiveness, the study examines the app’s usability, educational value, and learner feedback. The design follows user-centered principles to ensure accessibility for learners with different skill levels. Ultimately, this project seeks to demonstrate how AR, gamified learning, and 3D visualization can transform traditional classroom instruction into a more dynamic and effective process.

1.4 Objective of the Study

1.4.1 General Objective

Wonder Table is an Android-based Augmented Reality learning tool that enhances students' understanding and interest in the periodic table through engaging and interactive experiences.

1.4.2 Specific Objectives

- Designed and implemented a user-friendly application interface that ensures accessibility for learners with varying levels of technical proficiency.
- Developed an Augmented Reality (AR) based system capable of presenting interactive 3D models of periodic elements along with their corresponding properties.
- Incorporated interactive quizzes, primarily in a Multiple-Choice Question (MCQ) format, aimed at reinforcing learning, providing immediate feedback, and maintaining user engagement with the periodic elements' characteristics.
- Assessed the application's effectiveness through pre- and post-test comparisons and survey feedback to measure learning improvement, retention, motivation, and usability versus traditional teaching methods.

1.5 Scope and Limitations of the Study

The Scope of this study refers to the parameters under which the study will operate, and its limitations, such as the device's constraints.

1.5.1 Scope

This study focuses on the design, development, and evaluation of Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements. The Scope includes:

- The application provides AR-based 3D visualizations of periodic elements and atomic structures.
- The application creates detailed 3D models and animations of periodic elements using Blender.
- The application targets elementary, high school, and college learners. This broad Scope covers basic elements of atomic structure and periodic trends, utilizing AR visualization as a concrete learning tool for all.
- The application enhances learner engagement, comprehension, and retention compared to traditional methods.
- The application incorporates quizzes to reinforce knowledge and assess learner performance.
- The application demonstrates the potential of AR as a supplementary tool in science education.

1.5.2 Limitations

The following are the limitations of the application:

- The application is only available on Android and does not support iOS or Windows platforms.
- The application focuses only on periodic elements and atomic structures and does not cover the entire chemistry curriculum.
- The application is tested with a specific group of users, so the results may not reflect all types of learners.

- The application focuses on short-term learning effects and does not measure long-term knowledge retention.
- The application's effectiveness may vary depending on users' prior knowledge, device quality, and teaching style.
- The application depends on the device's camera and sensors for accurate 3D rendering and tracking.
- The application may encounter issues such as lag, limited device compatibility, or internet-related problems.
- The application measures learning engagement and understanding but does not directly track academic performance or grades.
- The application features basic interaction but lacks complex simulations or real-time animations found in more advanced systems.

1.6 Definitions for Terms

The following words are both conceptually and operationally defined based on this study.

- Android Application – Refers to the developed Wonder Table mobile software designed to enhance chemistry learning through Augmented Reality on Android devices.
- Atomic Mass – The average atomic weight of an element, shown as part of its detailed 3D representation within the Wonder Table system.
- Atomic Number – A displayed numerical value in the application that indicates the number of protons contained in an element's atom.
- Atomic Structure – The three-dimensional model of an atom displayed in the application, illustrating the arrangement of protons, neutrons, and electrons
- Augmented Reality (AR) – A technology utilized in the study that superimposes three-dimensional representations of periodic elements onto real-world environments, allowing interactive visualization through mobile devices.
- C# – The programming language used in developing the Wonder Table application, responsible for handling interactive features, quizzes, and system logic.
- Educational Technology – Refers to the use of digital tools and AR innovation, such as the Wonder Table application, to improve the quality and effectiveness of science instruction.
- Electron Configuration – The visual digital representation of the electron arrangement in each periodic element as presented in the Wonder Table system.
- Engagement in Learning – The degree to which learners actively interact with the Wonder Table system, reflecting their interest and motivation.
- Graphical User Interface (GUI) – The visual structure of the Wonder Table application that includes menus, icons, and buttons for user interaction.
- Human-Computer Interaction (HCI) – The process of designing the application interface to ensure smooth and intuitive interaction between the learner and the system.
- Interactive Learning – The learning approach adopted in this research promotes student engagement through direct manipulation and exploration of 3D periodic element models.
- Knowledge Retention – The ability of learners to recall and apply concepts after using the Wonder Table application.
- Molecular Composition – The visual demonstration within the application that shows how atoms combine to form molecules.
- Periodic Table – The main subject content of the Wonder Table application, presented in an interactive

and three-dimensional format to help learners understand the arrangement and properties of chemical elements.
- STEM Education – The educational framework in which this study is anchored, integrating science and technology through AR-based chemistry learning.
- 3D Visualization – The representation technique used in Wonder Table to display detailed and realistic atomic structures of elements, aiding conceptual understanding.
- Unity – The game development engine employed in this study for constructing the Wonder Table application and integrating Augmented Reality functionalities.
- User Experience (UX) – The overall perception and satisfaction of users while interacting with the Wonder Table application, measured in terms of usability and engagement.
- User-Friendly Interface – The application's interface was designed to ensure easy navigation and accessibility for learners with varying levels of technical knowledge.
- Vuforia Engine – The AR framework integrated within the Unity platform in this study, enabling image recognition, tracking, and projection of 3D models of periodic elements.

REVIEW OF RELATED LITERATURE AND SYSTEM

This chapter presents a review of related literature on systems relevant to the researcher’s study on "Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements." The following studies provide valuable insights into the development and effectiveness of AR-based learning tools for chemistry education.

2.1 Related Literature

2.1.1 Using Augmented Reality as a Powerful and Innovative Technology to Increase Enthusiasm and Enhance Student Learning in Higher Education Chemistry Courses (2021)

This study investigated how AR can be used in chemistry education to enhance enthusiasm and understanding among university students. It focused on using 3D molecular visualizations that allowed learners to manipulate chemical compounds from multiple angles. The researchers observed significant improvements in student engagement, motivation, and comprehension of molecular structures. About 87% of participants agreed that AR made learning chemistry more interactive and less abstract.

The immersive environment helped students visualize invisible processes, strengthening their spatial and conceptual understanding. Furthermore, AR replaced traditional 2D diagrams with dynamic experiences that improved recall. These findings demonstrate AR's potential as a transformative tool in scientific instruction. Similarly, Wonder Table applies the same principle to periodic elements rather than molecules, targeting a broader audience, including both high school and college students.

2.1.2 Application of Augmented Reality for Learning Material Structures and Chemical Equilibrium in High School Chemistry (2022)

This study introduced an AR application designed to teach chemical equilibrium and material structures to high school students. It utilized AR cards that allowed learners to observe reactions and visualize particle interactions in real time. The tool supported students' understanding of conservation of mass and submicroscopic representations in chemistry. Compared to traditional lectures, students who used AR reported higher motivation and a better conceptual grasp.

The researchers emphasized that the interactive nature of AR encouraged active learning instead of passive memorization. Through experimentation and manipulation, learners built stronger mental models of chemical processes. The study demonstrated how technology can make invisible reactions observable and comprehensible. Likewise, Wonder Table follows this approach by allowing users to explore atomic structures and periodic elements through interactive 3D models and quizzes, fostering both engagement and retention.

2.1.3 Fostering Motivation toward Chemistry through Augmented Reality Educational Escape Activities: A Self-Determination Theory Approach (2022)

This research examined the impact of AR-based escape room activities on student motivation and learning outcomes in chemistry. Guided by Self-Determination Theory, it analyzed how AR can enhance autonomy, competence, and relatedness in learning environments. Students participated in interactive problem-solving activities that required them to apply chemistry concepts to progress through levels. Although intrinsic motivation showed minimal change, extrinsic motivation and engagement levels increased significantly. Learners expressed enjoyment and satisfaction from the gamified learning experience.

The results confirmed that AR could promote collaborative learning and curiosity-driven exploration. Additionally, students appreciated the real-time feedback and visual cues provided during the activity. Similarly, Wonder Table integrates interactive quizzes and visual exploration to maintain engagement and motivation through constructive, technology-assisted learning.

2.1.4 Augmented Reality for Chemistry Education to Promote the Use of Chemical Terminology in Teacher Trainings (2022)

This system focused on improving the teaching competence of chemistry educators by introducing AR as a training tool for mastering scientific terminology. Teachers used AR-enhanced modules to visualize molecular structures and practice accurate use of chemical language. The study found significant improvement in teachers' understanding and confidence in explaining complex scientific concepts. The interactive 3D visuals helped them relate abstract terminology to real representations. Participants also reported increased classroom effectiveness and student responsiveness after integrating AR in their teaching practice.

The researchers concluded that AR bridges gaps between symbolic and conceptual knowledge in professional training. It underscores the adaptability of AR for both learners and educators in the science field. While the system is centered on teacher training, Wonder Table takes a learner-centered approach, simplifying periodic concepts through visualization and interactive quizzes that promote active learning.

2.1.5 Exploring the Effect of Augmented Reality on Cognitive Load, Attitude, Spatial Ability, and Stereochemical Perception (2022)

This study assessed how AR influences cognitive load and spatial ability in learning stereochemistry. Students were asked to interact with 3D AR models of chemical compounds to visualize molecular geometry and bonding. Results showed enhanced performance in spatial reasoning and academic achievement without increasing cognitive load. Learners reported that AR helped them understand molecular orientations that are hard to depict in flat illustrations.

The study demonstrated how AR can balance interactivity with information processing efficiency. Attitudes toward chemistry learning also improved due to the technology's engaging presentation. Researchers concluded that AR supports the dual process of learning and visualization by stimulating curiosity. In line with this, Wonder Table applies AR to periodic elements to simplify atomic structures while minimizing cognitive difficulty, helping users comprehend visual and symbolic representations effectively.

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2.1.6 An Investigation into Whether Applying Augmented Reality in Teaching Chemistry Enhances Chemical Cognitive Ability (2022)

The study developed "QuimiAR," an AR learning tool focused on teaching chemical bonding and molecular composition. It aimed to determine whether AR improves students' cognitive abilities in chemistry. Findings revealed that learners who used the system exhibited higher engagement and problem-solving skills. The tool encouraged critical thinking by allowing users to explore molecules in 3D. Compared with traditional instruction, AR users demonstrated better retention and conceptual understanding.

The interactive feedback mechanisms supported self-paced learning and exploration. Additionally, AR's visual realism helped eliminate misconceptions about molecular shapes and interactions. Similarly, Wonder Table adapts AR for learning periodic elements by emphasizing visualization and interactive learning to improve students' comprehension of atomic concepts.

2.1.7 Development of Augmented Reality as a Learning Tool to Improve Student Ability in Comprehending Chemical Properties of the Elements (2024)

Nazar et al. (2024) developed an AR tool using Unity, Vuforia, and Blender to teach students about the chemical properties of main group elements. The application allowed users to interact with 3D models, improving retention and comprehension. Evaluations showed that the app was visually appealing, efficient, and easy to navigate. The system proved highly effective in promoting self-directed learning. Students demonstrated better recall and understanding of periodic trends than in conventional instruction. The study underscored the advantages of integrating AR in chemistry education for conceptual clarity. Furthermore, AR technology was found to increase student interest and curiosity in science subjects. Similarly, Wonder Table uses Blender-based 3D models and interactive quizzes to help learners understand the periodic table in depth.

2.1.8 Integrating augmented reality into intelligent tutoring systems to enhance science education outcomes (2024)

This system combined Augmented Reality with Intelligent Tutoring Systems (ITS) to create a personalized science learning experience. The integration provided adaptive feedback, real-time assistance, and visual simulations across various chemistry topics. Students engaged with AR elements that responded dynamically to their input and learning pace. Findings showed increased motivation, understanding, and satisfaction compared to traditional methods.

The study also revealed that AR-ITS combinations can adapt to individual learning needs. This adaptive nature promoted inclusivity among students of varying abilities. Researchers concluded that AR enhances not only visualization but also the personalization of education. Wonder Table follows a similar interactive model but delivers universal accessibility instead of individualized tutoring, making it suitable for general classroom and self-paced learning environments.

2.1.9 Augmented Reality Interactive Experiences for Multi-Level Chemistry Education (2024)

This study explored the implementation of augmented reality (AR) in multi-level chemistry education, emphasizing its adaptability for both secondary and tertiary learners. The system provided interactive simulations and visual demonstrations that catered to different learning paces and abilities. Results revealed that AR enhanced conceptual understanding, engagement, and motivation across various academic levels. Educators reported that students benefited from real-time visualization of abstract topics, which improved comprehension and participation.

The research concluded that AR promotes inclusive, scalable, and dynamic science learning environments. In this regard, Wonder Table applies similar interactive AR features to accommodate diverse learners,

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supporting both high school and college students through accessible, visual, and engaging chemistry instruction.

2.1.10 Teaching with Augmented Reality Using Tablets, Both as a Tool and Object of Study in Chemistry Education (2023)

This study evaluated how tablets can be used both as instructional tools and subjects of study in chemistry education through AR integration. Students used AR-based tablets to explore sustainability concepts and battery reactions. The use of touch-enabled AR encouraged active experimentation and curiosity. Learners reported greater engagement and clearer conceptual understanding in applied chemistry lessons.

The researchers emphasized that mobility and interactivity were key to improving student attention and participation. Results indicated that AR transformed the classroom into a dynamic learning space. Moreover, the study demonstrated that AR-based learning can adapt to a wide range of topics beyond theoretical chemistry. Similarly, Wonder Table utilizes Android-based devices to promote foundational understanding of periodic elements through mobility, interactivity, and accessibility.

2.2 Related System

2.2.1 Applications of augmented reality (AR) in chemical engineering education: Virtual laboratory work demonstration to digital twin development (2024)

This study examined how AR could replace traditional 2D simulations in chemical engineering courses through virtual laboratories. Students interacted with immersive 3D visualizations of flow processes, equipment operations, and safety procedures. Findings revealed improved understanding and fewer laboratory errors among participants. AR promoted deeper conceptual learning by allowing users to visualize complex systems dynamically.

The study also noted increased student confidence in handling laboratory experiments. It concluded that AR provides an effective medium for bridging theory and practice. Researchers emphasized the scalability of AR for technical education and laboratory training. Likewise, Wonder Table applies AR to transform static periodic information into interactive visual learning that promotes a deeper understanding of atomic behavior.

2.2.2 ARChem App: Bringing Chemistry to Life (2024) ARChem App: Bringing Chemistry to Life (2024)

The ARChem application was developed to make molecular learning more interactive and engaging through augmented reality. It allowed students to manipulate molecular models in real time, providing an immersive environment for studying chemical bonding and geometry. The system enhanced comprehension by translating abstract formulas into visual structures. Students reported greater enjoyment and interest in chemistry due to the app's interactivity. Researchers observed that ARChem promoted long-term retention through repeated hands-on exploration.

The application demonstrated how visual tools can complement theoretical discussions in chemistry classes. The study concluded that AR has great potential to improve accessibility to complex scientific concepts. Similarly, Wonder Table applies AR to the periodic table, transforming static chemical information into interactive experiences, with quizzes for assessment.

2.2.3 Learn Chemistry with Augmented Reality (2020)

Bharti et al. (2020) created ARChemistry, an AR-based learning system designed to enhance visualization and logical reasoning in chemistry. The tool allowed learners to explore molecular structures from multiple perspectives. Students developed stronger connections between theoretical and visual representations of chemistry concepts.

The study showed that AR fosters active participation and curiosity. Participants reported higher motivation levels due to the novelty of interactive technology. Researchers found that the approach improved both comprehension and long-term knowledge retention. ARChemistry proved helpful across diverse age groups and educational levels. In the same way, Wonder Table focuses on periodic elements, ensuring that learners from elementary to tertiary education can engage effectively in chemistry concepts.

2.2.4 FOCAL: An Android Scanner of Periodic Table of Elements (2019)

FOCAL was an early AR-based Android application that scanned periodic table elements to project 3D representations and data. The system was praised for its accuracy, compatibility, and educational potential. Students found it easier to memorize and understand atomic information when visualized through AR. The app demonstrated how technology could make static charts more dynamic and engaging. Researchers observed that visual learning improved recall and reduced cognitive barriers. FOCAL also provided self-study accessibility outside the classroom. The study concluded that AR tools increase both comprehension and learning efficiency in science education. Wonder Table builds on this foundation by adding quizzes and detailed 3D animations that promote active exploration and reinforce learning.

2.2.5 Chemix: An Android-App Augmented Reality of the Periodic Table of Elements (2020)

Chemix introduced AR-based visualization of chemical elements for Android users, making chemistry learning more immersive. The app allowed learners to interact with 3D atomic structures and related data. Results indicated improved motivation and conceptual clarity among users. The technology provided immediate visual feedback, which enhanced engagement and comprehension.

Researchers emphasized the pedagogical benefit of integrating AR with mobile devices for easy accessibility. Students reported that AR encouraged independent exploration beyond classroom lectures. The system was recognized for promoting self-paced, experiential learning. Similarly, Wonder Table applies this concept by integrating quizzes that assess knowledge retention and encourage continuous learning.

2.2.6 Augmented Reality for Chemical Elements:Periodikar (2016)

PeriodikAR was one of the first AR applications developed to teach periodic elements through interactive animations. It presented dynamic visualizations of atomic number, mass, and electron configuration. Students gained a clearer understanding of atomic composition and relationships. The study confirmed that AR improves conceptual visualization by linking abstract data to tangible forms.

It also highlighted AR's potential to make chemistry more accessible to visual learners. Participants found the application enjoyable and effective for studying atomic properties. Researchers recommended using AR to enhance science engagement across educational levels. Building on this, Wonder Table integrates Blender-based animations and assessment features to support deeper learning and retention.

2.2.7 Chemistry AR: An Augmented Reality Application for Interactive Chemical Visualization (2023)

Chemistry AR+ is an augmented reality application developed to teach chemistry concepts through interactive 3D models and visual simulations. It presents molecular structures, atomic orbitals, and periodic trends in a dynamic way that enhances conceptual understanding. Students can manipulate elements, observe reactions, and visualize molecular bonding in real time, making abstract concepts more tangible and engaging. The application proved effective in improving comprehension and reducing misconceptions about chemical processes.

It also emphasized the importance of visual and experiential learning in increasing student motivation and participation. Users reported that Chemistry AR+ made chemistry lessons more interactive, enjoyable, and accessible. Building upon this concept, Wonder Table utilizes augmented reality to transform static

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periodic information into dynamic 3D experiences that promote deeper learning and long-term retention.

2.2.8 Learning the chemical elements through an augmented reality application for elementary school children (2022)

This study investigated the use of AR to simplify chemistry education for younger learners. It introduced a child-friendly app that presented atoms and molecules using colorful 3D visuals. The results demonstrated that AR significantly improved comprehension of abstract topics. Students showed heightened curiosity and enthusiasm toward science lessons.

Teachers reported that AR encouraged participation even among reluctant learners. The research emphasized the importance of interactive learning for early cognitive development. AR was shown to make science lessons more inclusive and enjoyable. Wonder Table adapts this visualization approach for older students, offering more detailed and scientifically accurate content suitable for high school and college levels.

2.2.9 Periodic Fable: Augmenting Chemistry with Technology, Characters, and Storytelling (2022)

The study by Olim et al. (2022) designed an AR-based educational game combining chemistry with storytelling to enhance learning outcomes. The system integrated character-based narratives that kept students engaged throughout lessons. Participants demonstrated improved motivation and understanding of chemical principles. The study showed that narrative-driven AR can effectively merge entertainment with education.

It encouraged emotional connection to learning material, enhancing recall and retention. Researchers highlighted the value of combining creativity and science through digital media. The findings indicated that AR storytelling supports holistic learning by merging imagination and knowledge. Although Wonder Table does not incorporate storytelling, it uses structured quizzes and interactive models that achieve similar levels of engagement and learning.

2.2.10 MicroWorld: An Augmented-Reality Arabian App to Learn Atomic Space (2022)

MicroWorld was an AR application developed to teach junior high students about atomic structures and subatomic particles. It provided 3D atomic models that users could rotate and zoom in for exploration. The study found that the application significantly improved comprehension and interest in atomic theory. Students developed better mental models of atomic space and configuration.

The research emphasized the effectiveness of interactive visualization in science learning. Usability testing confirmed that the app was accessible and engaging for its intended users. The authors concluded that AR enhances both motivation and understanding of chemistry fundamentals. Similarly, Wonder Table adopts Blender-rendered atomic models and interactive quizzes to make learning atomic structures more dynamic, engaging, and comprehensive.

DESIGN AND METHODOLOGY

In this chapter, the proponents present the design and development of Wonder Table, an Android-based learning tool for periodic elements. It discusses the conceptual framework, system architecture, user requirements, and the tools used to create the application.

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3.1 The Project Concepts

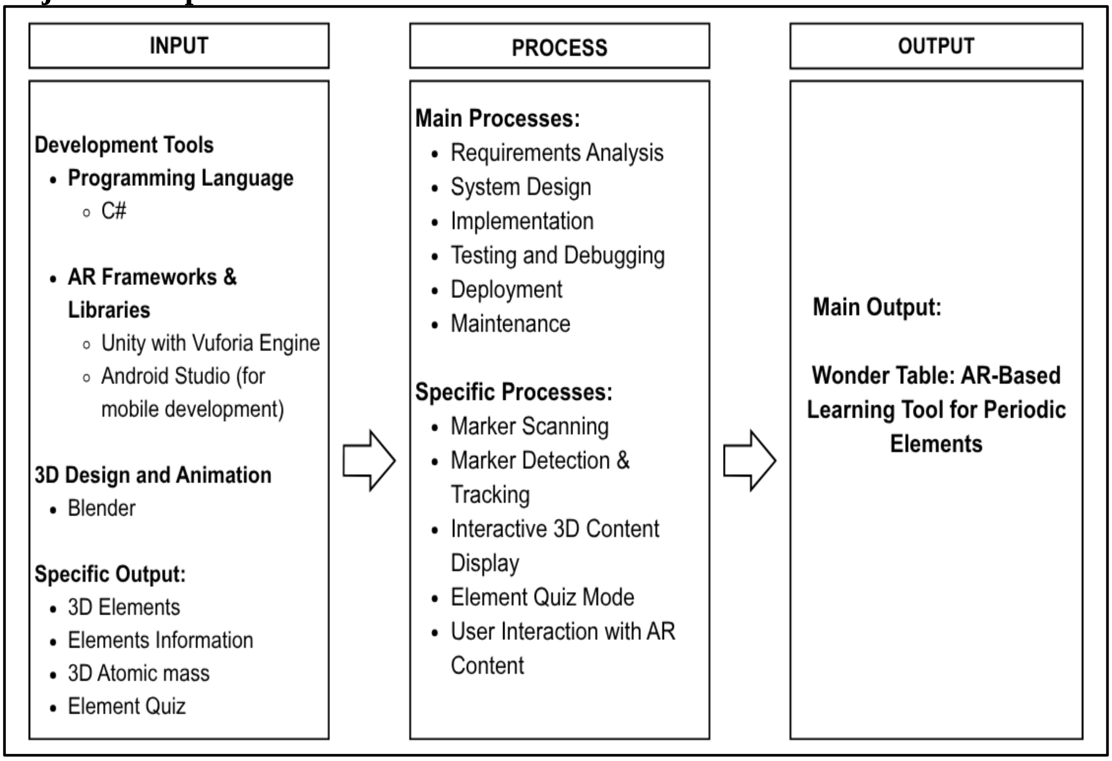

Figure 1 Project Concepts

Figure 1 shows the model of the Wonder Table application. The Input includes C#, Unity with Vuforia, Blender models, Android Studio, and periodic table data. The Process involves design, Testing, deployment, and tasks such as AR scanning, 3D rendering, element display, and quizzes. The Output is a mobile AR tool that lets students scan markers, view 3D atomic models, see details, and take quizzes with Feedback.

3.2 System Analysis and Design

3.2.1 User Requirements

Table 1. User Requirements

Name of the Project	Users	Module	Sub Module
Wonder Table: AR-Based Learning Tool for Periodic Elements	Student	Scanning	AR marker detection, Periodic table recognition, 3D element visualization
		Learning	Element information display (atomic number, mass, configuration, history)
		Interaction	Tap to view details, Rotate/zoom 3D models, Explore atomic structure

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		Quiz	Easy quiz, Hard quiz, Feedback (correct/wrong), Score display
		Navigation	Main Menu, Back, Exit
		System Requirements	Android compatibility, Camera & Sensor access, Stable AR tracking

Table 1 presents the six core modules of the Wonder Table app: Scanning, Learning, Interaction, Quiz, Navigation, and System Requirements. These modules work together to provide students with an engaging, functional, and educational AR learning experience.

3.2.2 Functional Requirements
3.2.2.1 Operational Environment

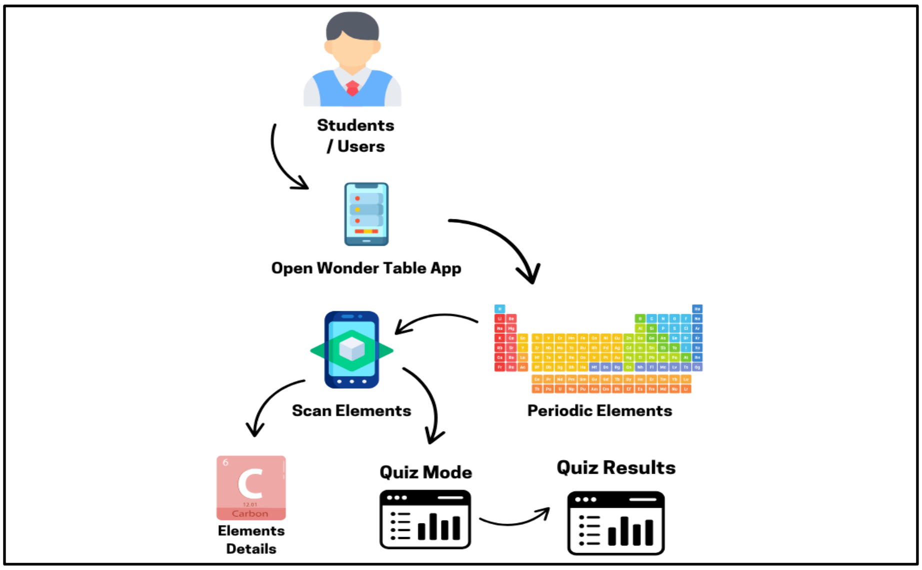

Figure 2 Operational Environment

Figure 2 shows the system interaction flow of the Wonder Table app. The student uses a mobile device to scan AR markers that display details of 3D elements, such as atomic number, symbol, and mass. The user can then enter Quiz Mode to answer assessments and receive immediate feedback on their performance, allowing them to review mistakes, track their progress, and reinforce learning before returning to the AR environment for continued exploration.

3.2.2.2 System Interface

The following are the components of the system interface used:

- The system utilizes a mobile device camera to scan AR markers and recognize periodic elements.
- The system requires device compatibility with the Vuforia Engine to support augmented reality features.

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- The user interface is designed to be intuitive and student-friendly, providing easy navigation through the AR scanning feature, periodic table viewer, and quizzes.
- The system runs on a Unity-based framework, with Blender-generated 3D models and C# scripts integrated to deliver interactive AR experiences without an external database.

3.2.2.3 Communication Interface

The communication interfaces that are utilized are as follows:

- C# - used as the primary programming language within Unity to implement interactive features such as AR object behavior, user interaction, and quiz functionality. It provides flexibility and efficiency in building the core logic of the AR application.

3.2.2.4 Software Interface

These are the software interfaces currently in use:

- Vuforia Engine – enables the application to detect and track AR image markers, allowing accurate rendering of periodic elements in augmented reality.
- Unity – serves as the primary development platform for building and deploying the AR application across Android devices.
- Blender – used to design and animate 3D atomic models of periodic elements, later integrated into Unity.
- Android Studio – used for APK testing, debugging, and deployment to ensure compatibility across Android devices.

3.2.2.5 Hardware Interface

Table 2. Hardware Interface

Hardware Interface	Function
Computer Unit	Utilized in system development and logical operations.
Mobile Phone	Utilized for developing and testing the AR application.
Power Supply Adapter/Charger	Delivers electrical power to a computer or mobile phone to supply it with energy.

Table 2 shows the hardware interface used by the proponents for the system's development.

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3.2.2.6 Use Case Diagram

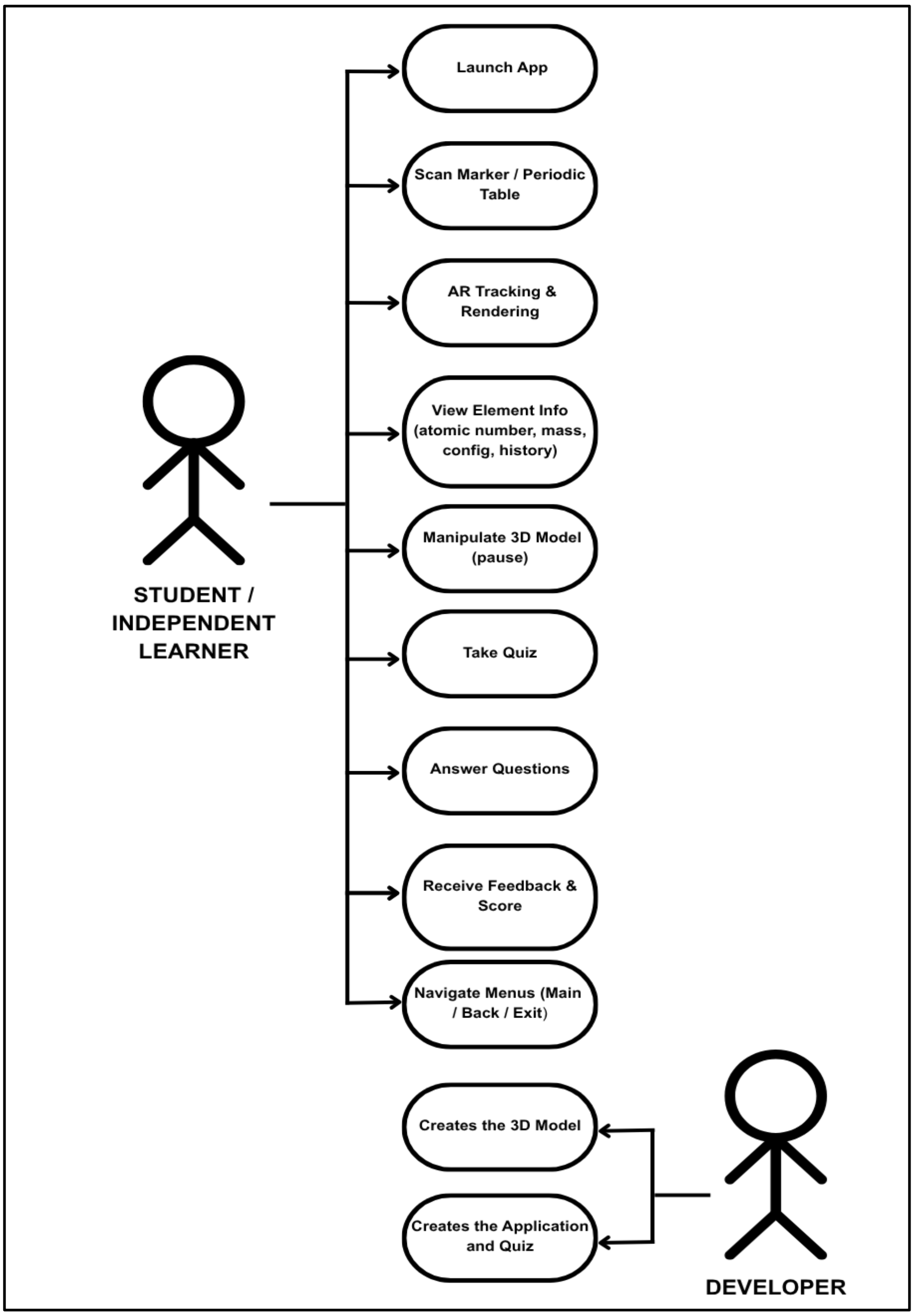

Figure 3 Use Case Diagram

Figure 3 shows the system flow, illustrating how students use the AR-based learning app by scanning markers to view and interact with 3D periodic elements, access quizzes, and receive Feedback. Developers create the app, 3D models, and quizzes that enable this interactive learning experience.

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3.2.2.7 User Group & System Access Summary

Table 3. User Group & System Access Summary

Users	System Access
Student	Can interact with the system via the mobile app. Students can scan periodic table markers to view 3D AR models of elements, read detailed information, and take quizzes or self-assessments to reinforce learning.
Independent Learner	Can use the app outside formal classroom settings for self-directed study. Independent learners can scan markers, explore 3D atomic models, and take quizzes to support their understanding of periodic elements.

Table 3 presents the user groups of the Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements and their corresponding system access. The Student user interacts with the application within a classroom or academic setting by scanning periodic table markers, viewing 3D AR models, reading detailed element information, and taking quizzes or self-assessments to reinforce learning. The Independent Learner user accesses the app outside formal classrooms for self-directed study, scanning markers, exploring 3D atomic models, and completing quizzes to strengthen their understanding of periodic elements. This classification ensures that the application supports both structured academic use and flexible independent learning.

3.2.3 Non-Functional Requirements

3.2.3.1 Reliability

- The system can provide users with accurate, consistent information about periodic elements through AR visualization.
- The AR marker recognition and 3D rendering are stable, ensuring smooth display of Blender-generated models during usage.
- The application maintains performance even in offline mode after installation, minimizing errors and interruptions.

3.2.3.2 Operability

- The system includes a clean, intuitive, and student-friendly interface that ensures ease of navigation through the AR features, periodic table viewer, and quizzes.
- The mobile application can be installed and used on Android devices without any additional configuration or backend systems.
- The operability is designed to support both students in formal education and independent learners using the application for self-study.

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3.2.3.3 Maintainability

The proponents will maintain the app through regular updates to enhance marker recognition, optimize 3D models, and improve quiz features. Project files are stored and version-controlled in GitHub to support future changes. The system design also allows new elements or content to be added without complete redevelopment.

3.2.3.4 Scalability

- The system is designed for a single user type: Student, but can also be used by independent learners. Functions such as AR viewing and quizzes are accessible to all users without requiring role-based modules.
- The application is scalable as more 3D periodic element models and quiz items can be added in future versions. The modular design of Unity and Vuforia enables additional features to be integrated without disrupting the existing system.

3.2.3.5 Availability

- The application will always be available for learners once installed on their Android devices.
- The system requires a mobile device with a functional camera and support for Vuforia Engine to render AR models correctly.
- No internet connection is required after installation, ensuring the app can be accessed offline anytime, anywhere.

3.2.4 System Requirements

The Wonder Table AR app requires specific hardware and software to run smoothly on mobile devices.

3.2.4.1 Hardware Requirements

To run the Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements smoothly, the following hardware specifications are necessary:

- OS: Android 8.0 or higher
- RAM: 4GB or above
- Storage: 64GB or above
- Camera: 8mp or above
- Processor: ARMv8 or better
- Internet: Optional (for updates)
- Display: 5.0" screen with at least 720p resolution

3.2.4.2 Software Requirements

Wonder Table combines design and programming tools to deliver full AR functionality and a user-friendly interface.

3.2.4.2.1 Frontend Development Tools

- Unity – the primary development platform used to build the AR mobile application.
- Vuforia Engine – AR SDK integrated into Unity to detect and track image markers.
- Blender – used to design and animate 3D atomic models of periodic elements.

3.2.4.2.2 Backend Development Tools

- Vuforia Emulator – used to simulate AR marker recognition without requiring a physical device during initial Testing.
- C# – programming language for interactivity, quizzes, and application logic.

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3.2.4.2.3 Testing and Debugging Tools

- Vuforia Emulator: Testing AR features without a device.
- Android Studio Debugger – used to test the APK on actual Android devices and identify errors.

3.2.4.2.4 Operating System

- Windows 11/10: For compatibility with Unity.

3.2.4.2.5 Network & Security

- Network: Required for updates; app works offline.
- Permissions: Camera and storage access only
- Data Privacy: No personal data collected.

3.2.4.2.6 Performance

- The app should launch within 6 to 10 seconds.
- 3D models should load in under 3.
- AR marker recognition should respond in real-time (less than 2 seconds delay).
- The app should function without noticeable lag on supported Android devices.

3.2.4.2.7 Backup and Recovery

- Source code stored in GitHub for version control.
- No user data backup required, as all is static.

3.3 Development Model

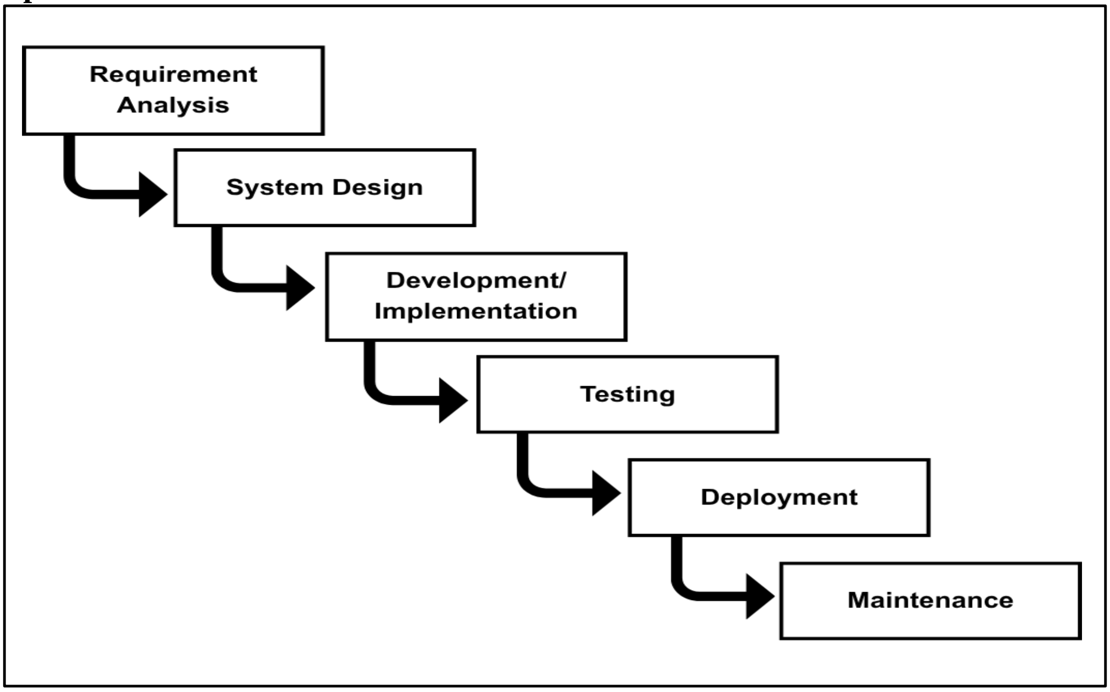

Figure 4 System Development Life Cycle (Iterative Waterfall Model)

Figure 4 shows the System Development Life Cycle (SDLC) followed in developing Wonder Table. It begins with Requirement Analysis, followed by System Design and Development/Implementation of features. The app then undergoes testing before being released in the Deployment phase. Finally,

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Maintenance ensures the system remains functional and up to date. This step-by-step model ensures the app is reliable, user-friendly, and effective for AR-based learning.

3.3.1 Requirements Analysis

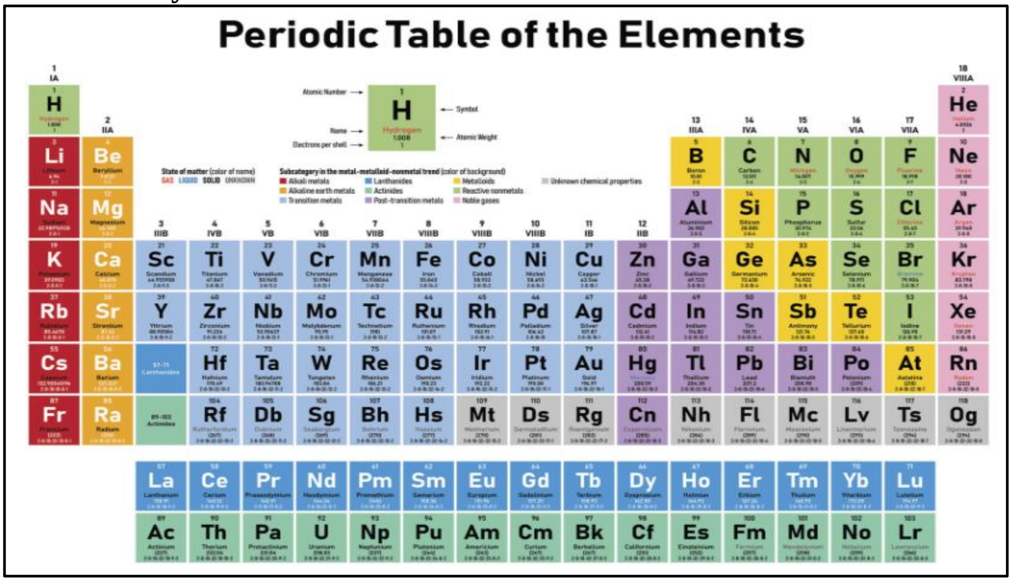

Figure 5 Periodic Table of the Elements

Figure 5 illustrates the complete Periodic Table of the Elements, which serves as the core learning dataset for the Wonder Table application. Each element is rendered with its corresponding details, including atomic number, symbol, and group classification. These visual and data components are integrated into the AR-based learning system, allowing students to interact with and explore atomic properties using their Android devices. This foundational table enables immersive visualization, interactive learning, and improved comprehension of elemental structure and relationships.

3.3.2 System Design

The system is designed to address the needs identified in the earlier stages. The modules developed by the proponents are clearly outlined in the design, serving as the foundation for the overall structure and functionality of the Wonder Table application.

3.3.2.1 Block Diagram

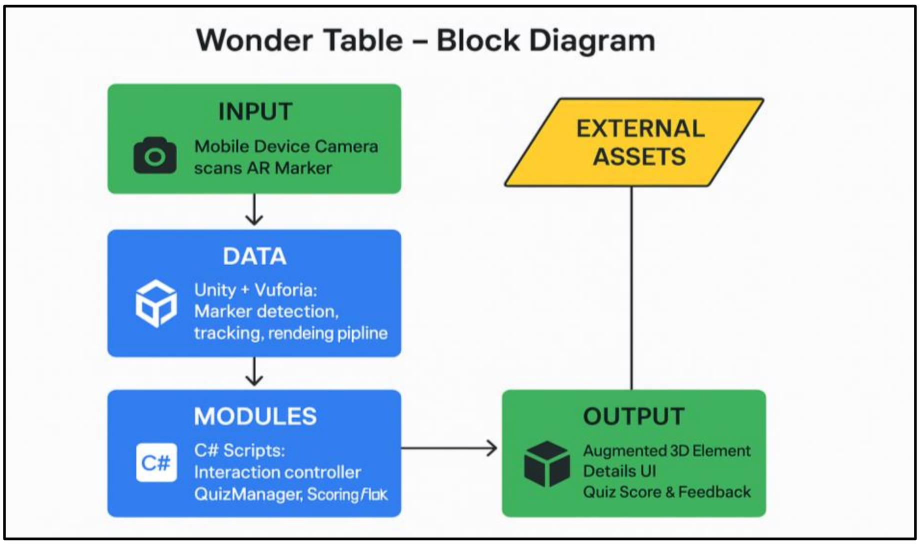

Figure 6 Block Diagram

Figure 6 shows the Wonder Table block diagram: the camera scans AR markers (Input), Unity with Vuforia processes tracking and rendering, C# Modules handle interactions and quizzes, and the Output displays 3D element models, details, and quiz results. Blender 3D models and element data support the AR experience.

3.3.2.2 Flow Chart

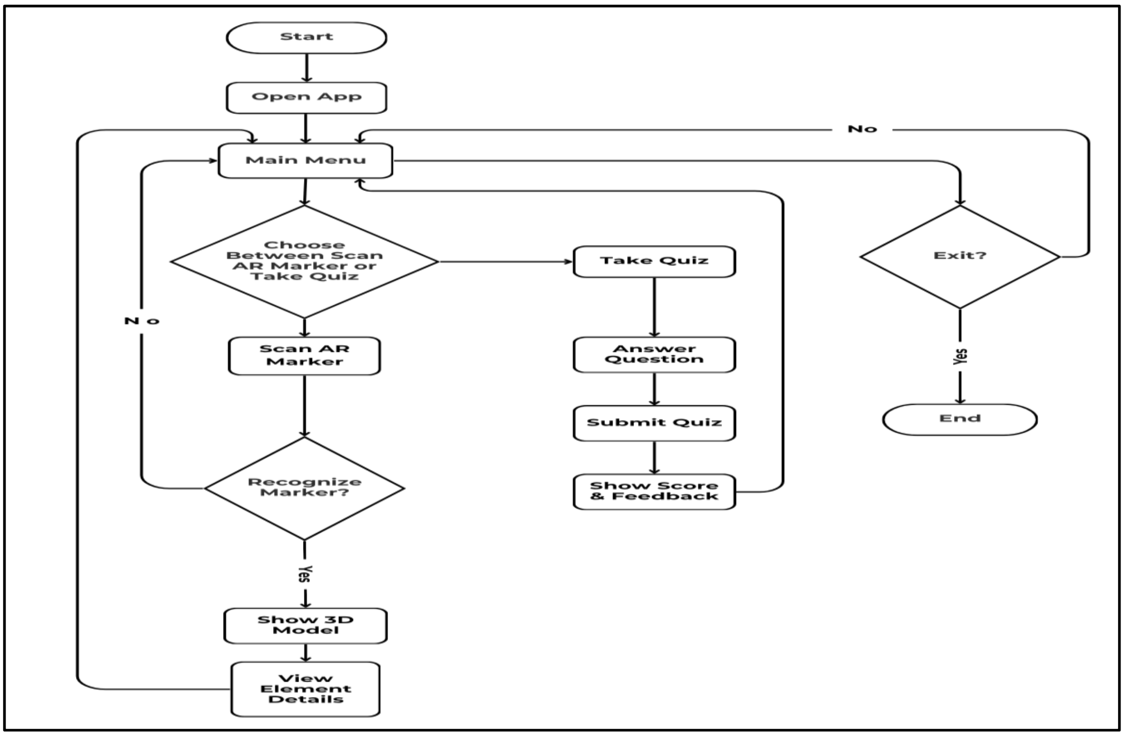

Figure 7 Flowchart

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Figure 7 shows the process flow of the Wonder Table application. The user begins by opening the app and accessing the Main Menu, where they may either scan an AR marker or take a quiz. Scanning displays the recognized element's 3D atomic model with detailed information, while the quiz option lets the user answer questions, submit responses, and view scores and feedback. After completing a task, the user can return to the main menu for another activity or exit the application.

3.3.2.3 AR Method

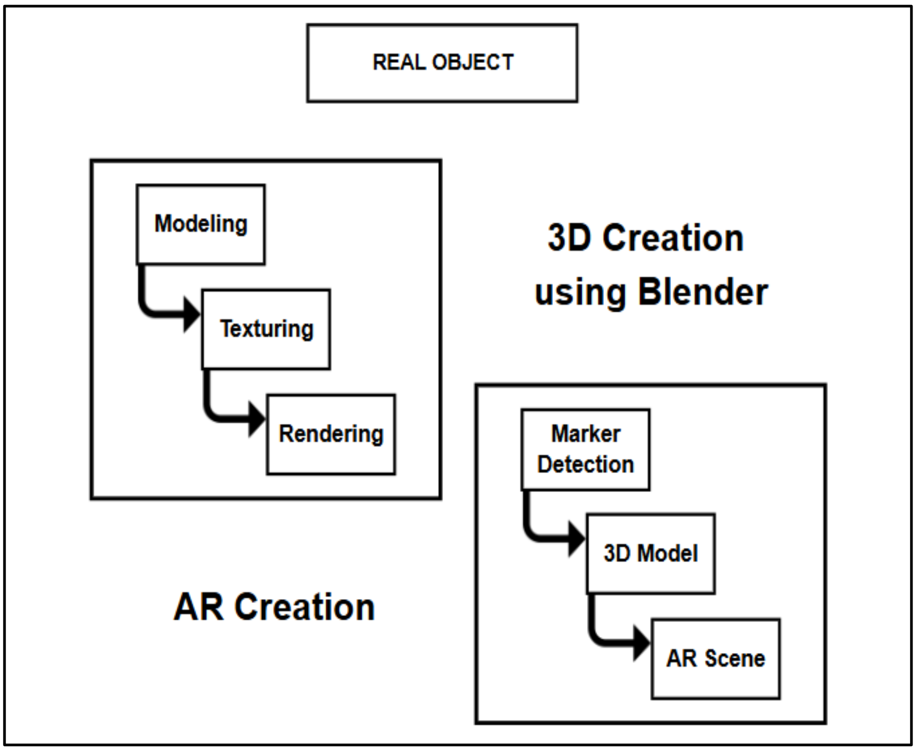

Figure 8 AR Method

Figure 8 illustrates the AR Method used in developing the Wonder Table application. The Process begins with 3D creation using Blender, where periodic elements are modeled, textured, and rendered to produce accurate atomic structures. These 3D assets are then integrated into Unity, where the Vuforia Engine manages marker detection and links the models to their corresponding image targets. Once the device camera recognizes a marker, the associated 3D model is rendered into the AR scene, allowing users to interact with the element in real time. This workflow demonstrates how Blender, Unity, and Vuforia were combined to transform real-world markers into immersive AR experiences.

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3.3.2.4 3D Model Creation Method

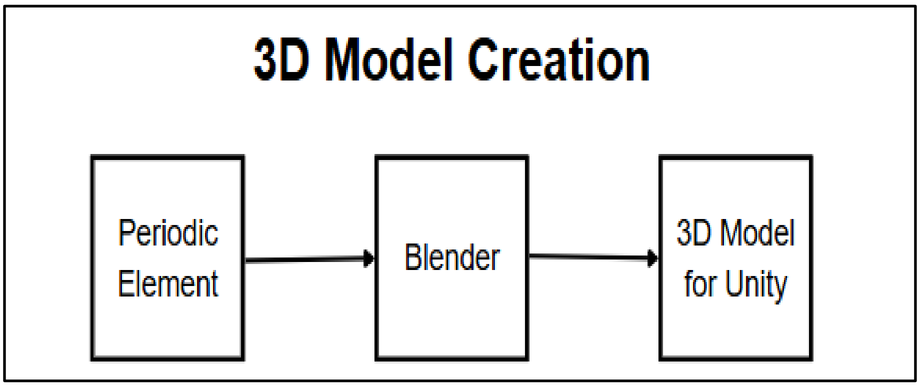

Figure 9 3D Model Creation Method

Figure 9 shows the Process of creating 3D models for Wonder Table. The Periodic elements were modeled and animated in Blender, then exported and imported into Unity, where they were integrated with the Vuforia Engine for augmented reality visualization.

3.3.2.5 Unity Vuforia Engine Environment

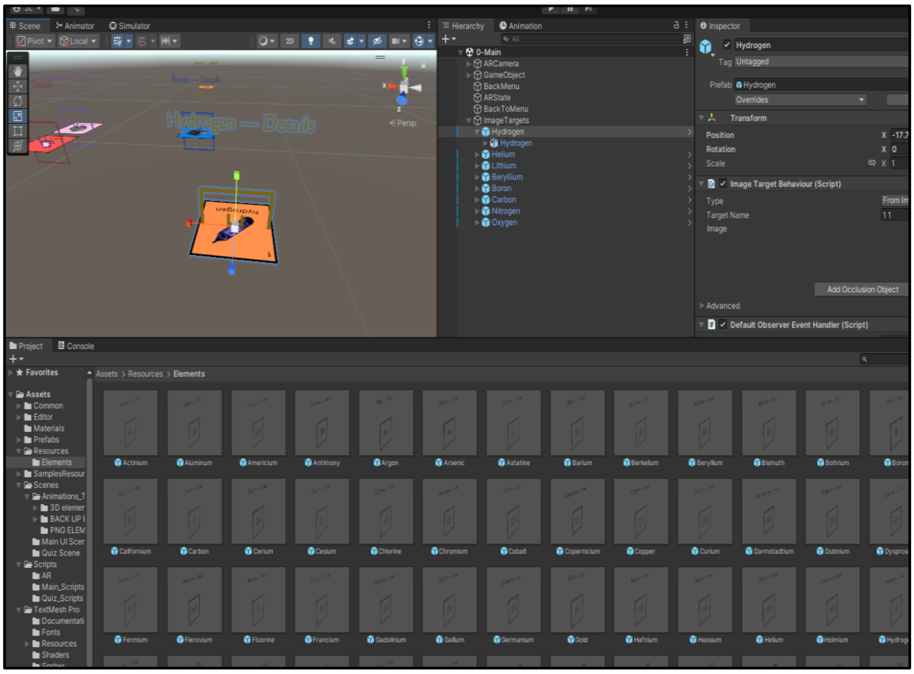

Figure 10 Unity AR Foundation

Figure 10 shows the Unity environment integrated with the Vuforia Engine, which was used to develop the Wonder Table application. This setup allowed the system to recognize image targets (AR markers) from the periodic table and accurately render corresponding 3D atomic models created in Blender.

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3.3.2.6 Blender

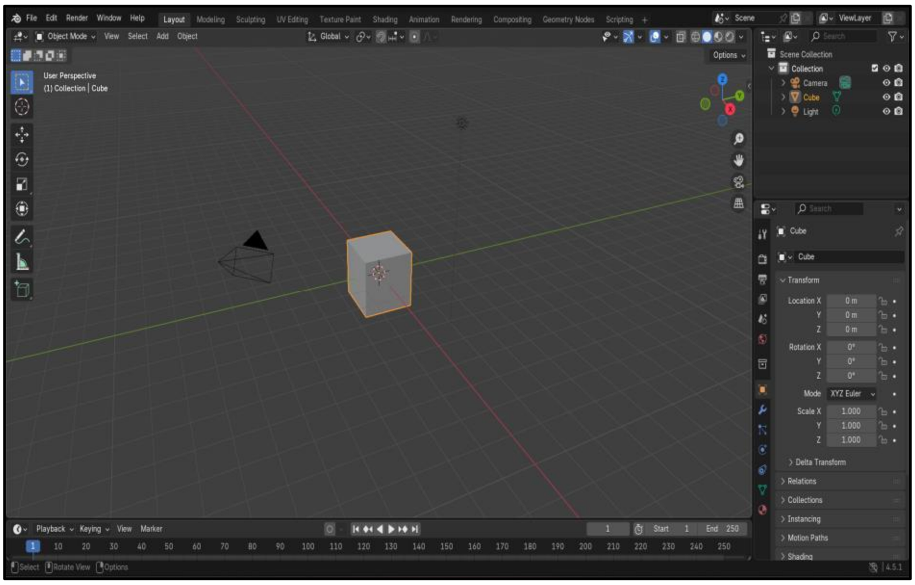

Figure 11 Blender

Figure 11 shows the use of Blender, an open-source 3D modeling and animation software, in the development of the Wonder Table application. Blender was utilized to design and animate atomic models of periodic elements, such as Thorium, by incorporating details including atomic number, mass, symbol, and electron configuration.

3.3.3 Implementation

During the implementation of the Wonder Table, the team deployed an interactive AR-based learning tool built with Unity and Vuforia Engine. 3D models of periodic elements were integrated and linked to image markers for real-time interaction via the device camera. Application logic, written in C#, utilized prefabs for animated, interactive components. A user-friendly interface enabled students to explore elements, take quizzes, and complete learning modules. Offline functionality was supported by embedding static data directly into the app, enabling full functionality without an internet connection.

3.3.4 Testing

Comprehensive Testing ensured a smooth, bug-free experience. Unit tests in Unity validated AR functions, while integration tests checked core module interactions. Usability tests with students assessed ease of use, and performance tests confirmed device compatibility. Real-world tests ensured accurate marker tracking under different lighting and distances.

3.3.5 Deployment

After Testing, the Wonder Table app was built into an APK using Unity and deployed to Android smartphones for classroom use and early access via sideloading. Deployment included version control with GitHub and distribution of user manuals and QR markers for hands-on AR learning.

3.3.6 Maintenance

After deployment, the app is regularly monitored for performance across Android devices. Feedback from students and teachers helps improve UI, loading speed, and quizzes. AR markers, 3D models, and learning content are updated via Unity projects managed in a GitHub repository. Maintenance also includes optimizing assets and scripts for better performance and battery efficiency.

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3.4 Development Approach

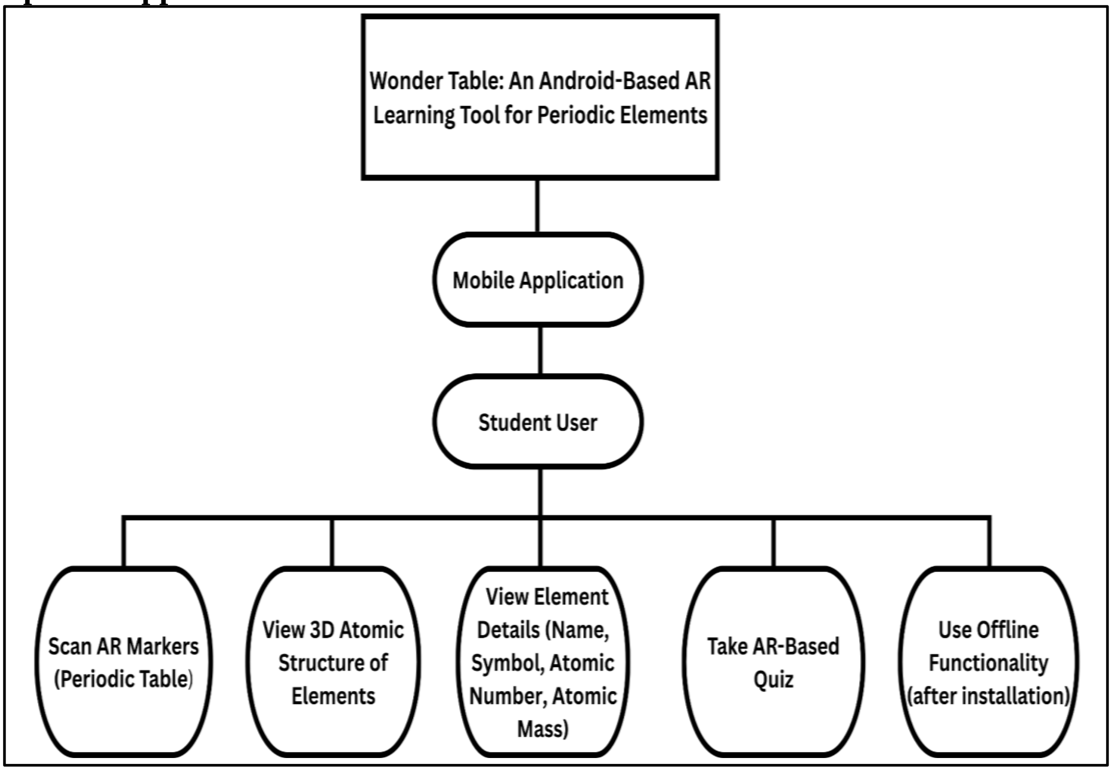

Figure 12 Top-Down Approach

Figure 12 shows the top-down approach used in developing Wonder Table. The system is centered on the Student User, who interacts with the mobile application to scan AR markers, view 3D atomic structures, access element details, take AR-based quizzes, and use offline functionality.

3.5 Software Development Tools

The Wonder Table application was developed using several software tools and platforms, including:

- Unity: The central development platform for building AR experiences, designing user interfaces, and scripting interactions using C#.
- Vuforia Engine – an AR SDK integrated with Unity to enable marker-based AR recognition and tracking of periodic table markers, ensuring accurate 3D model rendering.
- Android Studio: Utilized for testing APK builds and troubleshooting device-side issues using Logcat.
- GitHub: A version-controlled repository for managing source code and assets, enabling collaboration, backups, and version tracking.
- Unity Editor Play Mode with Vuforia Emulator – allowed developers to simulate AR interactions directly in the Unity editor without deploying every change to a physical device.

3.6 Timeline (Gantt Chart)

Table 4. Gantt Chart

Module	Start Date	End Date	Jan				Feb				May				Jun				Jul				Aug				Sep			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Planning	Jan 26 , 2025	Feb 8 , 2025																												
Title Hearing	Feb 15, 2025	Feb 16 , 2025																												
Proposal Defense	May 20, 2025	May 20 , 2025																												
Chapter 1	Jun 15 , 2025	Jun 19 , 2025																												
Chapter 2	Jun 19 , 2025	Jun 28 , 2025																												
Chapter 3	Jun 28 , 2025	July 18, 2025																												
Chapter 4	Aug 1 , 2025	Aug 14, 2025																												
Chapter 5	Aug 15 , 2025	Aug 29, 2025																												
Finalizing	Sept 1, 2025	Sept 10 , 2025																												
Final Defense	Sept 18 , 2025	Sept 18 , 2025																												

Table 4 visually represents the project's schedule and timeline through a Gantt chart. It outlines key tasks, milestones, and their corresponding durations to ensure effective project planning and management.

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3.7 Project Team and Responsibilities

Table 5. Project Team and Responsibilities

Name of Members	Appointment	Description
Bryce A. Corvera	Project Manager, Developer	Leads the project, manages tasks, and develops AR features in Unity with Vuforia.
James Ellison C. Lopez	Developer, Researcher, Designer	Creates 3D atomic models in Blender, designs UI, and supports documentation.
Bryan Peter P. Bacaling	Designer, Researcher	Creates 3D atomic models in Blender, designs the interface, enhances visuals, and assists with documentation, analysis, and testing.

Table 5 lists the project team members and their roles, ensuring precise task distribution and accountability.

3.8 Budget Cost Management Plan

Table 6. Hardware Cost

Description	Quantity	Amount
Laptop (Development)	2	95,000
Android Smartphone (Testing)	2	16,000
Total	4	111,000

Table 7. Utility Expenses

Description	Cost
Electricity (9 months)	11,000
Internet Subscription	1,800
Printing/Documentation	4,000
Total	16,800

Tables 6 & 7 present the combined expenses for hardware and utilities incurred during project development and Testing.

3.9 Verification, Validation, and Testing Phase

The Verification, Validation, and Testing Phase of Wonder Table ensured that the application met both technical requirements and user expectations. Verification involved unit testing key features, including AR marker recognition, 3D rendering, and quiz functionality, using Unity and Vuforia. Validation was conducted through usability testing with students and teachers to confirm that the app was engaging, easy to navigate, and effective for learning chemistry. Comprehensive Testing included functional checks, performance evaluations, and compatibility testing across various Android devices. Feedback and bug tracking were managed to refine the app and ensure it delivered a smooth, reliable, and educational AR experience.

3.9.1 ISO-1926-1 Instrument

The proponents used a System Usability Scale (SUS) to evaluate the application's functionality, reliability, efficiency, and overall usability. This scale is designed to capture user responses to specific questions, often reflecting extreme answers for clearer insights. In accordance with ISO 23488-2022, the survey was conducted via electronic platforms such as email, mobile devices, and web-based forms. Respondents rated the application on a five-point scale, with 5 as the highest and 1 as the lowest.

RESULTS AND DISCUSSION

The proponents surveyed 70 student respondents who tested the Wonder Table application. Respondents were selected based on their experience in using mobile devices for learning and their interest in exploring periodic elements through augmented reality. The survey aimed to evaluate the system's functionality, reliability, efficiency, and usability. The results were analyzed using statistical methods to determine how well the application enhanced the students' understanding of periodic elements. This chapter presents the findings, emphasizing the system's performance in the key areas mentioned.

4.1 Scientific Generalization

During testing, students used the app to scan markers, view 3D models, read element details, and take quizzes. Feedback showed that Wonder Table simplified chemistry concepts and made learning engaging through interactive visualization. Students praised its user-friendly design, clear information, and instant quiz feedback. The system met its objectives, offering accurate, offline AR learning with stable performance using Unity, Vuforia, and Blender.

4.2 Module Development

This part is where you can see the Chapter IV interface of the Wonder Table application, showcasing the front-end development that features an intuitive and visually engaging home page serving as the central hub for accessing key functions such as the periodic table, AR scanner, and quizzes, all designed to provide users with a smooth and interactive learning experience.

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4.2.1 Front End

4.2.1.1 Home Page

Figure 13 Mobile Home Page

Figure 13 shows the home page of the Wonder Table application, the main entry point for users. From this screen, the student can choose to start the application by accessing the AR scanning feature, navigate to the About section to learn more about the app and its usage, or exit the system entirely. The simple three-button design ensures user-friendliness and quick navigation, enabling both students and independent learners to access the application's core functionalities easily.

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4.2.1.2 About Page

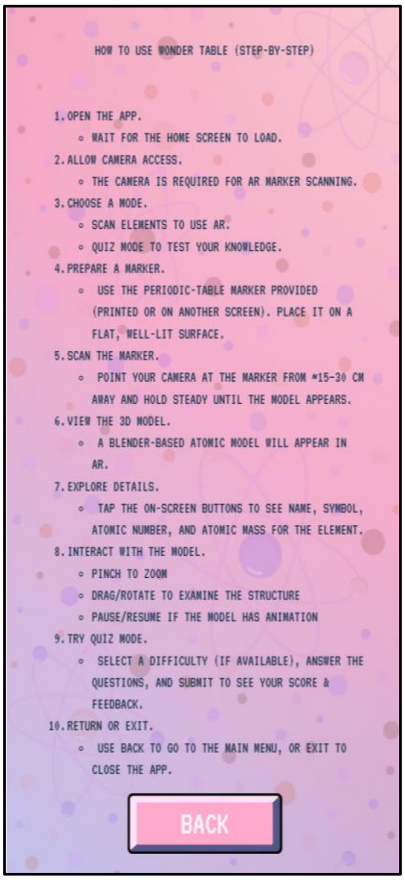

Figure 14 About Page

Figure 14 shows the About Page of the Wonder Table application, which provides a step-by-step guide for using the system. It explains how to scan markers, view 3D atomic models, access element details, and interact with models through pause. The page also guides users on taking quizzes and viewing results, ensuring that both students and independent learners can easily navigate the app.

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4.2.1.3 AR Scanner & Element Display Page

Figure 15 AR Scanner & Element Display Page

Figure 15 shows the AR Scanner & Element Display Page of the Wonder Table application, where the student scans a periodic table marker using the device camera. Once the marker is recognized, the system displays a Blender-generated 3D atomic model of the corresponding element. In this example, Oganesson, along with its details such as name, symbol, atomic number, and atomic mass, is being shown. The student can interact with the model by pausing animations, making the learning process more engaging.

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4.2.1.4 Quiz Main Page

Figure 16 Quiz Main Page

Figure 16 shows the Quiz Main Page of the Wonder Table application, where students can select the assessment difficulty level. The interface provides two options: Easy and Hard, allowing users to adjust the challenge according to their knowledge and confidence. Once a level is selected, the system presents a series of multiple-choice questions on periodic elements.

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4.2.1.5 Quiz Module Page

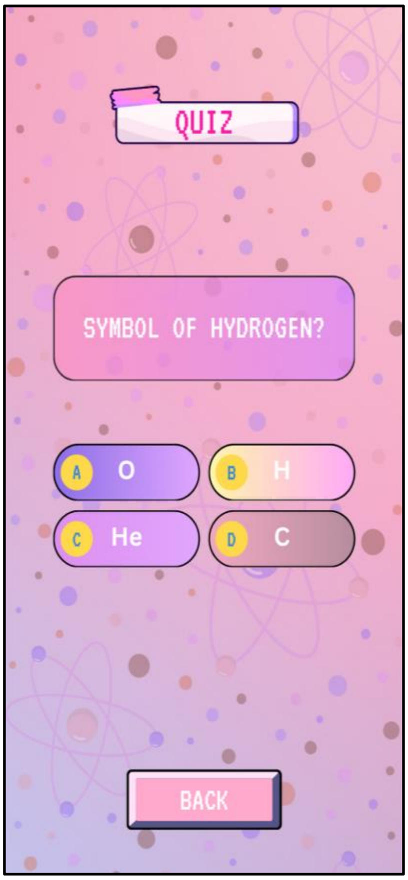

Figure 17 Quiz Module

Figure 17 presents the Quiz Module Page of the Wonder Table application, where students answer multiple-choice questions about periodic elements. The layout includes a question box at the top and four answer options labelled A, B, C, and D. Students can select their answer by tapping the corresponding option, then proceed to the next question.

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4.2.1.6 3D Model Creation using Blender

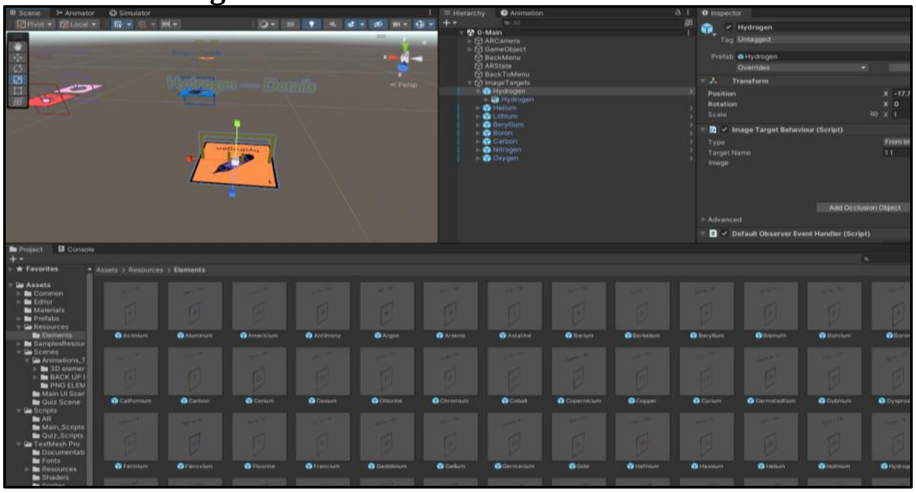

Figure 18 3D Model Creation using Blender

Figure 18 shows the process of creating 3D atomic models in Blender and integrating them into Unity. Blender was used to design and animate the models of periodic elements, including details such as atomic number, symbol, and mass. These models were then exported and imported into Unity, where they were linked with Vuforia image targets to enable AR visualization.

4.2.1.7 Mobile Creation using Unity

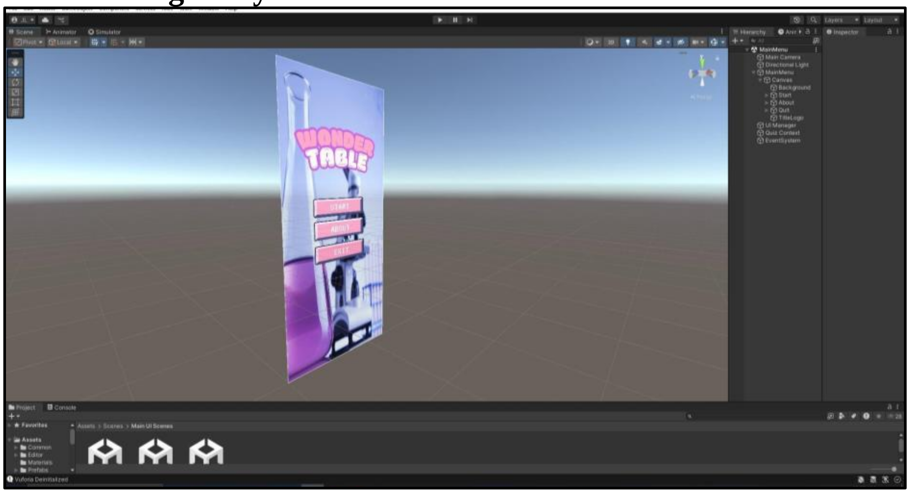

Figure 19 Mobile Creation using Unity

Figure 19 The Wonder Table application was developed as a mobile AR learning tool using Unity, a powerful game engine widely used for 3D and interactive content creation. Unity served as the main development environment where the 3D models of periodic elements, animations, and user interface layouts were integrated into a single mobile-ready project. With the help of Unity's AR support and plugins, the app was optimized to run smoothly on Android devices while maintaining high-quality graphics and responsiveness.

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4.3 Use Cases

Table 8. Use Cases

USERS	CASES
Student / Independent Learner	Can scan AR markers to view 3D atomic models of periodic elements
Student / Independent Learner	Can take quizzes to test knowledge and receive instant feedback.
Student / Independent Learner	Can view element details such as name, symbol, atomic number, and mass.

Table 8 presents the main functions available to students or independent learners, including scanning AR markers, taking quizzes, and viewing detailed information about periodic elements.

4.4 Statistical Treatment

The mean was used to evaluate the effectiveness of Wonder Table across functionality, reliability, efficiency, and usability. A 5-point Likert scale was employed, where five (5) represented the highest rating and one (1) the lowest

To provide a qualitative description, the means were interpreted according to the following ranges: The range of mean scores is interpreted as follows: a score of 4.21 to 5.00 indicates the system is highly functional, highly reliable, highly efficient, and highly usable; 3.21 to 4.20 means it is functional, reliable, efficient, and usable; 2.61 to 3.20 reflects moderate functionality, reliability, efficiency, and usability; 1.81 to 2.60 shows it is less functional, less reliable, less efficient, and less usable; and 1.00 to 1.80 indicates the system is not functional, not reliable, not efficient, and not usable.

4.5 International Organization for Standardization Result

After conducting the survey, which utilized ISO 23488-2022 standards, the ratings gathered from the 20 student respondents were calculated using the same instrument. The proponents arrived at the following results:

4.5.1 Result

Table 9. Functionality Result

Functionality	5	4	3	2	1	Total	AWV
1. The app scans and recognizes periodic table markers.	13	6	1	0	0	20	4.60
2. The app overlays 3D atomic models of elements accurately.	10	7	3	0	0	20	4.35
3. The app responds quickly when scanning and displaying content.	6	11	3	0	0	20	4.15
4. The app works well with the device's camera and hardware.	7	10	3	0	0	20	4.20

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5. The app allows the user to view and interact with 3D models and read element details.	9	9	3	0	0	20	4.25
						Mean:	4.31

Table 9 shows an overall mean of 4.31, rated Highly Functional, indicating that Wonder Table effectively scans markers, displays 3D models, and enables smooth, accurate interaction, proving it a reliable AR learning tool.

Table 10. Reliability Result

Reliability	5	4	3	2	1	Total	AWV
1. The system loads 3D atomic models of elements quickly and smoothly.	9	6	4	1	0	20	4.05
2. The app operates without sudden crashes or technical interruptions.	7	9	5	0	0	20	4.15
3. AR marker scanning is consistent and responsive during use.	15	1	3	1	0	20	4.00
4. The system provides reliable access to element details (name, symbol, atomic number, mass).	8	9	4	0	0	20	4.25
5. The app maintains stable performance across different devices.	6	1	4	0	0	20	4.10
						Mean:	4.11

Table 10 shows the overall mean for the Reliability Result is 4.11, which corresponds to a descriptive rating of Reliable. It suggests that the Wonder Table application performs consistently, loads 3D models effectively, scans markers responsively, and operates without major technical issues, ensuring a smooth user experience for students and independent learners.

Table 11. Usability Result

Usability	5	4	3	2	1	Total	AWV
1. The app is easy to use, understand, and navigate.	12	6	2	0	0	20	4.50
2. The interface is student-friendly and visually engaging.	10	8	2	0	0	20	4.40
3. Students enjoy using the AR feature to scan elements and explore 3D models.	9	9	2	0	0	20	4.35
4. The app provides an interactive learning experience with quizzes and instant feedback.	8	10	2	0	0	20	4.30

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5. The system enhances learning by making periodic elements more fun and engaging.	7	11	2	0	0	20	4.25
						Mean:	4.36

Table 11 shows that the overall mean for Usability Result is 4.36, corresponding to a descriptive rating of Usable. It indicates that Wonder Table is user-friendly, enjoyable, and effective in making periodic elements interactive and engaging for students and independent learners.

Table 12. Efficiency Result

Efficiency	5	4	3	2	1	Total	AWV
1. The app loads quickly and responds without noticeable delay.	11	7	3	0	0	20	4.45
2. The AR marker recognition works efficiently under normal conditions.	10	8	2	0	0	20	4.40
3. The 3D atomic models display smoothly without performance issues.	9	9	2	0	0	20	4.35
4. The quiz system processes answers and provides feedback instantly.	8	10	2	0	0	20	4.30
5. The app uses device resources (camera, storage, AR engine) efficiently.	7	11	2	0	0	20	4.25
						Mean:	4.35

Table 12 shows the overall mean for the Efficiency Result is 4.35, with a descriptive rating of Efficient. This indicates that Wonder Table performs smoothly, loads quickly, and processes AR features and quizzes without delay, ensuring a practical, seamless learning experience.

Table 13. Overall Result

Overall	5	4	3	2	1	Total	AWV
1. The user is very satisfied with the overall experience of using Wonder Table to explore and learn about periodic elements.	6	12	2	0	0	20	4.20
						Mean:	4.20

Table 13 shows the overall mean for the Overall Result is 4.20, with a descriptive rating of Highly Functional, Reliable, Usable, and Efficient. It indicates that students and independent learners were satisfied with Wonder Table's ability to simplify complex chemistry concepts through AR, making science learning interactive, accessible, and engaging.

4.5.2 Summary

Table 14. ISO 23488-2022 Summary Result

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Software Quality Factors	Mean Average	Descriptive Rating
Functionality	4.27	Highly Functional
Reliability	4.18	Reliable
Usability	4.36	Usable
Efficiency	4.35	Efficient
Mean:	4.29	Highly Acceptable

Table 14 shows the result from the evaluation of the Wonder Table application. Functionality obtained a mean average of 4.27, rated as Highly Functional. Reliability received a mean of 4.18, indicating it is reliable. Usability achieved a mean of 4.36, rated as Usable, while Efficiency recorded a mean of 4.35, rated as Efficient. of 4.36, rated as Usable, while Efficiency recorded a mean of 4.35, rated as Efficient.
The overall mean of 4.29 indicates that the system is Highly Acceptable, confirming that users found Wonder Table to be functional, reliable, efficient, and user-friendly. These results demonstrate that the application successfully supports interactive learning through AR, meeting the objectives of the study.

4.6 Survey Quiz Result (Easy and Hard)

To measure the learning effectiveness of the Wonder Table AR tool, two quiz sets (easy and hard) were given under traditional and AR-based conditions. In the first phase, students used printed materials before taking the quizzes. In the second phase, they used the Wonder Table app to explore 3D elements and then took the same quizzes. It allowed direct comparison of performance between traditional and AR-enhanced learning.

Table 15. Summary of Students' Quiz Performance under Traditional and AR-Based Methods

Difficulty Level	Traditional Mean Score	AR-Based Mean Score	Mean Difference	Interpretation
Easy Quiz	7.8 / 10	9.1 / 10	1.3	Improved with AR
Hard Quiz	6.5 / 10	8.3 / 10	1.8	Improved with AR
Overall Mean:	7.15 / 10	8.7 / 10	1.55	Significant Improvement with AR

Table 15 shows that students performed better on quizzes when using the AR-based learning method than with the traditional approach. In the easy quiz, the average score improved from 7.8 in the conventional method to 9.1 with the AR method, marking an increase of 1.3 points. Likewise, in the challenging quiz, the mean score increased from 6.5 (traditional) to 8.3 (AR-based), reflecting a 1.8-point improvement.
These results reveal that the Wonder Table AR application significantly enhanced students' understanding and retention of the periodic elements. The 3D models and interactive simulations enabled learners to visualize atomic structures and chemical symbols, fostering deeper conceptual understanding.
The greater improvement observed on the challenging quiz suggests that AR technology is particularly effective at clarifying complex or abstract chemistry concepts that students typically struggle to grasp with traditional materials. The dynamic, visual environment offered by AR helped bridge the gap between theoretical discussion and the actual visualization of elements.

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Overall, the mean difference of 1.55 points across both quiz types confirms that learners benefited more from the digital AR-assisted approach. The combination of interactivity, instant feedback, and visual engagement fostered greater focus, motivation, and knowledge retention than conventional instruction.
In summary, the results provide strong evidence that the Wonder Table AR learning tool outperforms traditional methods in promoting both fundamental (easy) and advanced (hard) understanding of periodic elements.

4.7 Survey Questionnaire

The purpose of this study is to compare traditional learning (books) with digital learning (Wonder Table AR App) in understanding periodic elements among Elementary, High School, and College students.

4.7.1 Survey Questionnaire Result

Table 16. Section A: Elementary

Questions:	1	2	3	4	5	Total:	AWV
1. The book lesson helped me understand the elements.	0	0	4	6	10	20	4.30
2. The book lesson was fun and interesting.	0	0	7	7	6	20	3.95
1. The book lesson was easy to use and follow.	0	0	5	8	7	20	4.10
2. I want to learn again using the book lesson.	0	0	7	6	7	20	4.00
3. The book lesson helped me remember the elements.	0	0	10	3	7	20	3.85
4. The AR app helped me understand the elements.	0	0	5	9	6	20	3.95
5. The AR app helped me remember the elements.	0	0	8	5	7	20	3.80
6. The AR app was fun and interesting.	0	0	6	6	8	20	3.95
7. The AR app was easy to use and follow.	0	0	9	4	7	20	3.75
8. I want to learn again using the AR app.	0	0	7	6	7	20	4.05
Mean:							3.97

Table 16 shows that most of the 20 elementary students rated the traditional lesson and the Wonder Table AR tool positively. Half strongly agreed and 30% agreed that the AR app helped them understand the elements. Overall, younger learners found the interactive AR approach engaging and effective for learning.

Table 17. Section B: High School

Questions:	1	2	3	4	5	Total:	AWV
1. The traditional lesson helped me understand periodic elements.	0	0	12	5	3	20	3.55
2. The traditional lesson helped me remember the symbols and properties of elements.	0	0	9	4	7	20	3.90

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3. The traditional lesson was interesting and engaging.	0	0	6	7	7	20	4.05
4. The traditional lesson was easy to follow and study with.	0	0	6	7	7	20	4.05
5. I would like to keep using traditional lessons for Chemistry.	0	0	8	6	6	20	3.90
6. The AR app helped me understand periodic elements more clearly.	0	0	7	8	5	20	3.75
7. The AR app helped me remember element details better than the book.	0	0	3	8	9	20	4.20
8. The AR app was more engaging and enjoyable than the traditional lesson.	0	0	7	6	7	20	3.90
9. The AR app was easy to use and navigate.	0	0	5	7	8	20	4.10
10. I would like to keep using AR apps like Wonder Table for Chemistry.	0	0	6	6	8	20	4.10
Mean:							3.95

Table 17 shows responses from 20 high school students comparing traditional lessons and the Wonder Table AR tool. Many selected "Neutral" for Questions 1 and 2, but most agreed on the AR app's engagement, enjoyment, and ease of use (Questions 7–10). Overall, high school learners value AR learning while still balancing it with traditional methods.

Table 18. Section C: College

Questions:	1	2	3	4	5	Total:	AWV
1. The traditional lesson helped me understand periodic elements.	0	0	6	4	10	20	4.20
2. The traditional lesson helped me remember the symbols and properties of elements.	0	0	9	6	5	20	3.80
3. The traditional lesson was interesting and engaging.	0	0	8	5	7	20	3.95
4. The traditional lesson was easy to follow and study with.	0	0	9	4	7	20	3.90
5. I would like to keep using traditional lessons for Chemistry.	0	0	4	12	4	20	4.00
6. The AR app helped me understand periodic elements more clearly.	0	0	8	6	6	20	3.90
7. The AR app helped me remember element details better than the book.	0	0	9	3	8	20	3.95
8. The AR app was more engaging and enjoyable than the traditional lesson.	0	0	6	8	6	20	4.00
9. The AR app was easy to use and navigate.	0	0	8	5	7	20	3.95

10. I would like to keep using AR apps like Wonder Table for Chemistry.	0	0	7	5	8	20	4.05
Mean:							3.97

Table 18 shows feedback from 20 college students on traditional Chemistry lessons and the Wonder Table AR tool. Most strongly agreed that the AR app improved understanding and retention of atomic structures. Overall, results indicate that college students value AR as an effective and innovative complement to traditional instruction.

Table 19. Overall Survey Result Across Educational Levels

Educational Level	Overall Mean	Verbal Interpretation
Elementary	3.97	Agree
High School	3.95	Agree
College	3.97	Agree
Overall Combined Mean:	4.08	Agree

Table 19 summarizes the survey results from 60 respondents at the elementary, high school, and college levels regarding the Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements. With an overall mean of 4.08 (Agree), students from all levels showed positive perceptions of the system's usefulness, engagement, and efficiency. The results indicate that learners found the AR app's interactive features and 3D visuals effective in simplifying chemistry concepts. Overall, the findings confirm that Wonder Table enhances understanding and makes science learning more engaging compared to traditional methods.

SUMMARY, CONCLUSIONS, AND RECOMMENDATION

This chapter discusses the study's findings and summarizes the overall outcome of developing the Wonder Table application. General conclusions are presented, followed by recommendations to improve the system and guide future research.

5.1 Summary of the Findings

The study titled "Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements" aimed to compare the effectiveness of traditional learning and augmented reality (AR) based learning in understanding the periodic elements. The research involved three groups of participants representing different educational levels.

The survey and survey quizzes were conducted at:

- Butuan Christian Community School for elementary and high school students.
- Caraga State University for college students, selected randomly from various departments.

Results revealed that all three educational levels exhibited positive perceptions of the AR-based learning method. The overall mean scores were 3.97 for Elementary, 3.95 for High School, and 3.97 for College, with an overall combined mean of 4.08 (Agree). It indicates that students found the AR learning experience effective, engaging, and easy to use.

In the survey quizzes, performance also improved under the AR condition. Students achieved a higher mean score of 8.7/10 using the Wonder Table app, compared to 7.15/10 with traditional learning, a mean difference of 1.55 points. The improvement was more evident in the challenging quiz, where AR-based learning helped learners better visualize and understand complex chemistry concepts.

These findings suggest that AR technology significantly enhances both conceptual understanding and retention in science education. It also demonstrates that students across grade levels benefit similarly from interactive, visual learning tools like the Wonder Table app.

5.2 Conclusions

The findings reveal that the Wonder Table successfully met its objectives by providing an accurate and reliable AR-based learning tool. Students found the application effective in simplifying complex concepts through visualization and interactive features. The quiz module, with instant scoring and feedback, proved to be a valuable reinforcement tool. The system demonstrated high functionality, usability, and efficiency, supported by stable performance across devices. By integrating Unity, Vuforia, and Blender, the application delivered an immersive learning experience that not only increased student engagement but also improved comprehension of periodic elements.

Based on the objectives and findings of this study, it can be concluded that the Wonder Table: An Android-Based Augmented Reality Learning Tool for Periodic Elements effectively achieved its intended goals. The application provided a user-friendly interface, ensuring accessibility for learners with varying levels of technical proficiency. It presented interactive 3D models of periodic elements and their properties, enabling students to visualize complex concepts in an engaging, comprehensible way. Through interactive quizzes in a Multiple-Choice Question (MCQ) format, the system reinforced learning, provided immediate feedback, and maintained user engagement. Finally, assessment of learning outcomes through pre- and post-tests and survey feedback demonstrated improved student understanding, retention, motivation, and usability compared to traditional teaching methods. Overall, the study confirms that the Wonder Table serves as an effective, accessible, and interactive AR-based supplementary learning tool that enhances chemistry education across different educational levels.

5.3 Recommendations

To further enhance the Wonder Table system, several improvements are recommended. The quiz module may be refined by adding additional question categories, difficulty levels, and interactive feedback mechanisms, and by integrating a scoring history or leader board feature to foster healthy competition and motivation among learners. In terms of content expansion, the application could include more comprehensive information on chemical elements, including their common compounds, practical uses in daily life, and safety precautions, along with multimedia content such as videos or animations to enrich the learning experience. For technical enhancements, marker recognition optimization in low-light or noisy environments and improvements in 3D rendering speed are encouraged to ensure stable performance across devices, including those with lower hardware specifications. Enhancing user accessibility through adjustable text sizes, audio narration, and multilingual support would promote inclusivity and usability for a broader range of learners.

To sustain learner interest and engagement, integrate gamification elements, badges, rewards, and time-based challenges to encourage continuous participation. Expanding offline functionality will enable users to access more educational materials and quizzes without an internet connection, making the system more adaptable to regions with limited connectivity. For educators, developing a teacher's dashboard or

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companion tool is suggested to facilitate performance tracking, custom quiz creation, and classroom integration. Furthermore, future researchers may explore the application of artificial intelligence to provide adaptive learning paths and personalized recommendations based on student interaction data. In terms of scalability, extending the concept to other scientific fields such as physics and biology, using augmented reality simulations and 3D models could further broaden its educational scope. Finally, deploying.

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APPENDICES A
RELEVANT SOURCE CODE

```
using UnityEngine;

Unity Script (1 asset reference) | 14 references
public class QuizContext : MonoBehaviour
{
    public static QuizContext I;         // <-- the singleton your code is using

    public Element SelectedElement;
    public Difficulty SelectedDifficulty;

    Unity Message | 0 references
    void Awake()
    {
        if (I != null && I != this) { Destroy(gameObject); return; }
        I = this;
        DontDestroyOnLoad(gameObject);
    }
}
```

Figure 20 Code Snippet

Figure 20 illustrates the implementation of the QuizContext class in Unity, which functioned as a singleton to manage quiz-related data across different game scenes. The script ensured that only one instance of QuizContext existed during gameplay, maintaining the selected quiz elements and difficulty settings. Within Awake(), any duplicate instances were destroyed to preserve a single active object. Additionally, the DontDestroyOnLoad() function allowed the object to persist between scenes, ensuring that the player's quiz data remained consistent throughout the game.

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```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using UnityEngine.SceneManagement;
using Vuforia;

Unity Script (233 asset references) | 0 references
public class ARQuizGate : MonoBehaviour
{
    [Header("UI")]
    [SerializeField] Button quizButton;                  // drag your overlay Btn_Quiz here
    [SerializeField] CanvasGroup quizButtonCanvasGroup;      // OPTIONAL: CanvasGroup on Btn_Quiz (not parent
    [SerializeField] string quizMenuSceneName = "QuizMenu";

    [Header("Behavior")]
    [Tooltip("Delay after losing tracking before disabling (prevents flicker).")]
    [SerializeField] float lostGraceSeconds = 0.4f;

    [Tooltip("Fade duration for the QUIZ button.")]
    [SerializeField] float fadeSeconds = 0.25f;

    // runtime
    readonly List<ObserverBehaviour> observers = new();
    readonly Dictionary<ObserverBehaviour, ElementId> idByObserver = new();
    Element currentElement = default;
    Coroutine lostRoutine, fadeRoutine;

    Unity Message | 0 references
    void Awake()
    {
        // start hidden/disabled
        SetQuizEnabled(false, instant: true);
    }

    Unity Message | 0 references
    void OnEnable() => SubscribeAll();
    Unity Message | 0 references
    void OnDisable() => UnsubscribeAll();

    // ---------------------------------------------------------------------
    // Vuforia hookups
    // ---------------------------------------------------------------------
    1 reference
    void SubscribeAll()
    {
        UnsubscribeAll();

        foreach (var ob in FindObjectsOfType<ObserverBehaviour>(true))
        {
            // find an ElementId anywhere on this target's hierarchy
            var id = ob.GetComponent<ElementId>()
                    ?? ob.GetComponentInParent<ElementId>(true)
                    ?? ob.GetComponentInChildren<ElementId>(true);
            if (!id) continue;
```

Figure 21 Code Snippet

Figure 21 shows a portion of the script that manages the quiz button's behavior in the Unity application. The code defined parameters such as fade duration and tracking delay, ensuring smooth visual transitions and stable interactions. It also initialized runtime observers and enabled and disabled event subscriptions. These functions helped maintain consistent interface behavior and responsiveness during gameplay.

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```
using UnityEngine;

Unity Script | 0 references
public class BobAndPulseUI : MonoBehaviour
{
    public RectTransform target;
    public float bobAmplitude = 6f;
    public float bobSpeed = 1f;
    public float pulseAmount = 0.08f;
    public float tiltDegrees = 3f;

    Unity Message | 0 references
    void Reset() { target = GetComponent<RectTransform>(); }
    Unity Message | 0 references
    void Update()
    {
        if (!target) return;
        float t = Time.unscaledTime * bobSpeed;
        float s = 1f + Mathf.Sin(t) * pulseAmount;
        target.localScale = new Vector3(s, s, 1f);
        var p = target.anchoredPosition; p.y = Mathf.Sin(t) * bobAmplitude; target.anchoredPosition = p;
        target.localRotation = Quaternion.Euler(0, 0, Mathf.Sin(t * 0.7f) * tiltDegrees);
    }
}
```

Figure 22 Code Snippet

Figure 22 presents a script segment that handles the bobbing and pulsing animation of a UI element within the Unity environment. The script defined parameters such as bobAmplitude, bobSpeed, pulseAmount, and tiltDegrees to control vertical motion, scaling effects, and rotational tilt. During each frame update, mathematical sine functions generated smooth oscillations, creating a rhythmic bobbing and pulsing motion. It enhanced the interface's visual appeal and dynamism, making the targeted element appear more interactive and engaging.

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```
using UnityEngine;
using UnityEngine.SceneManagement;
using Vuforia;

public class ARTargetQuizLauncher : MonoBehaviour
{
    [SerializeField] GameObject quizPanel; // child Canvas with a Quiz button
    ObserverBehaviour ob; ElementId id;

    void Awake()
    {
        ob = GetComponent<ObserverBehaviour>();
        id = GetComponent<ElementId>();
        if (quizPanel) quizPanel.SetActive(false); // hidden until tracked
    }

    void OnEnable() { if (ob) ob.OnTargetStatusChanged += OnStatus; }
    void OnDisable() { if (ob) ob.OnTargetStatusChanged -= OnStatus; }

    void OnStatus(ObserverBehaviour _, TargetStatus s)
    {
        bool tracked = s.Status == Status.TRACKED || s.Status == Status.EXTENDED_TRACKED;
        if (quizPanel) quizPanel.SetActive(tracked);
    }

    // Hook this to the child button's OnClick
    public void OnQuizPressed()
    {
        if (QuizContext.I && id) QuizContext.I.SelectedElement = id.element;
        SceneManager.LoadScene("QuizMenu");
    }
}
```

Figure 23 Code Snippet

Figure 23 shows a script segment that controls the visibility and interaction of a quiz button in the Unity application. The code initialized components, such as ObserverBehaviour and ElementId, to monitor the target-tracking status. During the initialization phase, the quiz panel was hidden until a tracking event occurred. Using event subscriptions defined in OnEnable and OnDisable, the script dynamically updated the panel's visibility in response to real-time status changes. It ensured the quiz button appeared only when the corresponding target was detected, maintaining a seamless, responsive user experience during augmented reality interactions.

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```
using UnityEngine;
using UnityEngine.SceneManagement;

Unity Script (3 asset references) | 0 references
public class QuizMenuUI : MonoBehaviour
{
    [SerializeField] string levelSceneName = "Level1"; // gameplay scene
    [SerializeField] string backSceneName = "0-Main"; // back to AR

    0 references
    public void GoEasy() => StartQuizWith(Difficulty.Easy);
    0 references
    public void GoHard() => StartQuizWith(Difficulty.Hard);
    0 references
    public void GoBack() => SceneManager.LoadScene(backSceneName);

    2 references
    void StartQuizWith(Difficulty d)
    {
```

Figure 24 Code Snippet

Figure 24 presents a script that manages scene transitions in the Unity-based quiz application. The code defined serialized fields for storing the gameplay scene (levelSceneName) and the return scene (backSceneName). It incorporated functions that handled user-selected difficulty levels, such as Easy or Hard, and navigated accordingly to the appropriate gameplay environment. Additionally, the script provided a method for returning to the main augmented reality interface when required. By managing scene transitions through the SceneManager.The LoadScene method ensured smooth navigation and consistent state handling between quiz sessions and the main AR environment.

```
Unity Script (1 asset reference) | 0 references
public class QuizManager : MonoBehaviour
{
    [Header("UI: Assign from scene")]
    public Text questionText;                        // UI/Question
    public Text scoreText;                           // UI/Score
    public Text finalScore;                          // UI/GameFinished/Score
    public Text bestScoreText;                       // NEW: UI/Best (optional)
    public Button[] replyButtons = new Button[4];    // UI/Replies (4 buttons)
    public GameObject Right;                         // UI/Right banner
    public GameObject Wrong;                         // UI/Wrong banner
    public GameObject GameFinished;                  // UI/GameFinished panel

    [Header("Data")]
    public QtsLibrary library;                       // Drag your QtsLibrary asset here
    public QtsData qtsData;                          // Auto-set from library + QuizContext
    public Difficulty difficulty = Difficulty.Easy;

    [Tooltip("How many questions to ask this round (0 = use all for the chosen difficulty)")]
    public int questionsPerRound = 0;

    [Header("Timings")]
```

Figure 25 Code Snippet

Figure 25 presents a script segment that manages the quiz gameplay settings and runtime logic within the Unity-based quiz application. The code defined several serialized fields for linking GameObjects, such as UI banners (Wrong and GameFinished), and for importing question data through the QstLibrary. It also allowed developers to configure gameplay parameters, including the difficulty level, the number of questions per round, and the duration of feedback display. Additional serialized fields, such as quizMenuSceneName, specified navigation targets within the application. During runtime, private variables such as deck, currentIndex, score, and correctButtonIndex were initialized to track player

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progress and control the quiz flow. Overall, this script served as a foundational component for initializing quiz parameters, managing feedback timing, and ensuring smooth quiz operations throughout gameplay.

```
using UnityEngine;
using UnityEngine.SceneManagement;

public class ARUIController : MonoBehaviour
{
    // Top-right Quiz button in your AR scene
    public void OnQuiz()
    {
        SceneManager.LoadScene("QuizMenu");
    }

    // Bottom-center Back button (AR -> Main menu)
    public void OnBackToMenu()
    {
        SceneManager.LoadScene("MainMenu");
```

Figure 26 Code Snippet

Figure 26 shows a script that handles navigation controls between scenes in the Unity-based AR quiz application. The OnQuiz() method was triggered when the user tapped the quiz button in the AR interface, redirecting them to the quiz scene (QuizMenu) through the SceneManager.LoadScene function. Similarly, the OnBackToMenu() method allowed users to return from the AR or quiz environment to the main menu (MainMenu). In addition, the Update() function monitored the Android hardware back key (KeyCode.Escape), providing a seamless means for mobile users to navigate backward without relying solely on on-screen buttons. Overall, this script enhanced usability by integrating both UI- and hardware-based navigation methods, ensuring a smoother, more intuitive AR learning experience.

```
using System.Collections.Generic;
using UnityEngine;

[CreateAssetMenu(fileName = "QtsLibrary", menuName = "Quiz/QtsLibrary")]
public class QtsLibrary : ScriptableObject
{
    [Tooltip("Add one QtsData per element (Hydrogen, Helium, etc.). " +
             "Duplicates/nulls will be cleaned automatically.")]
    public List<QtsData> banks = new List<QtsData>();

    // Fast lookup at runtime
    Dictionary<Element, QtsData> _map;

    void OnEnable() => BuildMap();
    void OnValidate() => BuildMap(); // keeps it tidy in the editor

    void BuildMap()
    {
```

Figure 27 Code Snippet

Figure 27 presents a C# code snippet for the BuildMap() method, which organizes and cleans data within the application to ensure efficient access. The technique began by initializing a dictionary (_map) designed to store unique Element objects and their corresponding QtsData. It validated the input list of "banks" before proceeding. The main logic iterates through the list, filtering out null entries and preventing duplicates based on the Element key, following a "first one wins" approach. After processing, the method replaced the original list with a cleaned version containing only valid and unique entries. Additionally, the inclusion of OnValidate() and BuildMap(); ensured that this process ran automatically in the Unity Editor, thereby maintaining consistent, accurate data structures during development.

```
using System.Collections.Generic;
using UnityEngine;

[System.Serializable]
public class Choice
{
    public string text;
    public bool isCorrect;
}

[System.Serializable]
public class QuestionItem
{
    public string prompt;
    public List<Choice> choices = new List<Choice>(); // 2-4 choices; mark one isCorrect = true
}

[CreateAssetMenu(fileName = "QtsData", menuName = "Quiz/QtsData")]
public class QtsData : ScriptableObject
{
    public Element element;
    public List<QuestionItem> easy = new List<QuestionItem>();
    public List<QuestionItem> hard = new List<QuestionItem>();
    public List<QuestionItem> calculation = new List<QuestionItem>();
```

Figure 28 Code Snippet

Figure 28 presents a script that defines the data structure and organization of quiz questions within the Unity application. The QuestionItem class stored each question's text along with a list of possible answer choices, with one marked as correct. The QstData class, derived from ScriptableObject, managed categorized question lists (easy, hard, and calculation) and provided a GetByDifficulty() method to retrieve questions based on the selected difficulty level. The [CreateAssetMenu] attribute allowed developers to easily create and manage quiz data assets directly from the Unity Editor. This script formed the backbone of the question management system, enabling efficient data storage, organization, and retrieval for dynamic quiz generation.

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```
using UnityEngine;
using UnityEngine.SceneManagement;
using UnityEngine.Android;
using System.Collections;

Unity Script (3 asset references) | 0 references
public class MainMenu : MonoBehaviour
{
    [SerializeField] string arSceneName = "0-Main";
    [SerializeField] string aboutSceneName = "About";

    // ----- START (AR with camera permission) -----
    0 references
    public void StartAR()
    {
        StartCoroutine(LoadARScene());
    }

    1 reference
    private IEnumerator LoadARScene()
    {
        // Request camera permission only when launching AR
        if (!Permission.HasUserAuthorizedPermission(Permission.Camera))
        {
            Permission.RequestUserPermission(Permission.Camera);
```

Figure 29 Code Snippet

Figure 29 presents a C# code snippet from a Unity application that handles scene loading, specifically for an Augmented Reality (AR) scene that requires camera permissions. The coroutine method LoadARScene() managed the process by first checking if the necessary camera access had been granted using Permission.HasUserAuthorizedPermission(). If not, it requested Permission through Permission.RequestUserPermission() and paused execution using yield return null until the user responded. Once Permission was granted, the AR scene was loaded via SceneManager.LoadScene(arSceneName). Additionally, the GoAbout() method provided a simple way to load the standard "About" scene, ensuring smooth, permission-compliant transitions between scenes in the application.

```
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using Vuforia;

Unity Script (1 asset reference) | 0 references
public class ARPauseController : MonoBehaviour
{
    [Header("Target root that contains all ImageTargets (e.g., ImageTargets)")]
    [SerializeField] Transform contentRoot;

    [Header("UI")]
    [SerializeField] Button pauseButton;
    [SerializeField] Button resumeButton;
    [SerializeField] CanvasGroup dimPanel;   // optional

    [Header("Options")]
    [Tooltip("Detach child content from ImageTargets while paused so it stops following the marker.")]
    [SerializeField] bool freezeFollowingMarker = true;

    [Tooltip("Alpha to use on the dim panel when paused.")]
    [Range(0, 1f)] public float dimAlpha = 0.35f;

    // --- runtime state ---
    bool isPaused;

    readonly List<(Animator anim, float speed)> anims = new();
    readonly List<ParticleSystem> particles = new();
    readonly List<(AudioSource audio, bool wasPlaying, float time)> audios = new();
```

Figure 30 Code Snippet

Figure 30 presents a C# script snippet for a Pause Manager used in a Unity AR application. The script included serialized fields such as a resumeButton, a diePanel for the pause overlay, a

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freezeFollowingMarker boolean to stop AR content from tracking its marker, and a dimAlpha value for screen fading effects. It maintained an isPaused state and several read-only lists to store active components, such as Animators, Particle Systems, and Audio Sources so that they could be paused and restored correctly. A freezeRoot Transform served as a temporary parent for AR content when the game was paused. Within Awake(), the script initializes by turning off the resume button and configuring the pause button to trigger Pause().

```
public enum Element
{
    // 1-20
    Hydrogen,    // 1
    Helium,      // 2
    Lithium,     // 3
    Beryllium,   // 4
    Boron,       // 5
    Carbon,      // 6
    Nitrogen,    // 7
    Oxygen,      // 8
    Fluorine,    // 9
    Neon,        // 10
    Sodium,      // 11
```

Figure 31 Code Snippet

Figure 31 shows a C# code snippet that defines a public enumeration named Element. This enumeration represented a fixed set of named constants, providing a structured and type-safe way to reference specific items within the application. The members corresponded to the first several chemical elements, such as Hydrogen, Helium, and Lithium, listed sequentially. Each element name was paired with an integer value, where the comments (e.g., // 1, // 2) suggested mapping to their respective atomic numbers. This Element enumeration served as a key data structure in the AR application, allowing the system to uniquely identify and manage individual elements being displayed or interacted with.

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APPENDICES B
SURVEY QUESTIONNAIRE

Part I: Personal Information

Please provide necessary information as a respondent.

Name (Optional): ______________________

Address: ____________

Part II: Survey Proper

Select the choice that best reflects your experience in using the Wonder Table application.
Use the scale where 5 is the highest (excellent) and 1 is the lowest (poor).

5 - Excellent: Works perfectly, very engaging.
4 - Good: Works well, minor issues.
3 - Average: Works fine, needs improvement.
2 - Below Average: Has several problems.
1 - Poor: Barely works at all.

Software Quality Statement	Level of Agreement

Functionality	5	4	3	2	1
1. The app scans and recognizes periodic table markers.					
2. The app overlays 3D atomic models of elements accurately.					
3. The app responds quickly when scanning and displaying content.					
4. The app works well with the device's camera and hardware.					
5. The app allows the user to view and interact with 3D models and read element details.					

Reliability	5	4	3	2	1
1. The system loads 3D atomic models of elements quickly and smoothly.					
2. The app operates without sudden crashes or technical interruptions.					
3. AR marker scanning is consistent and responsive during use.					

4. The system provides reliable access to element details (name, symbol, atomic number, mass).					
5. The app maintains stable performance across different devices.					

Usability	5	4	3	2	1
1. The app is easy to use, understand, and navigate.					
2. The interface is student-friendly and visually engaging.					
3. Students enjoy using the AR feature to scan elements and explore 3D models.					
4. The app provides an interactive learning experience with quizzes and instant feedback.					
5. The system enhances learning by making periodic elements more fun and engaging.					

Efficiency	5	4	3	2	1
6. The app loads quickly and responds without noticeable delay.					
7. The AR marker recognition works efficiently under normal conditions.					
8. The 3D atomic models display smoothly without performance issues.					
9. The quiz system processes answers and provides feedback instantly.					
10. The app uses device resources (camera, storage, AR engine) efficiently.					

1	**Excellent**
2	**Good**
3	**Average**
4	**Below Average**
5	**Poor**

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Survey Question for Elementary:

Questions:	1	2	3	4	5
1. The book lesson helped me understand the elements.					
2. The book lesson was fun and interesting.					
3. The book lesson was easy to use and follow.					
4. I want to learn again using the book lesson.					
5. The book lesson helped me remember the elements.					
6. The AR app helped me understand the elements.					
7. The AR app helped me remember the elements.					
8. The AR app was fun and interesting.					
9. The AR app was easy to use and follow.					
10. I want to learn again using the AR app.					

Survey Question for High School:

Questions:	1	2	3	4	5
1. The traditional lesson helped me understand periodic elements.					
2. The traditional lesson helped me remember the symbols and properties of elements.					
3. The traditional lesson was interesting and engaging.					
4. The traditional lesson was easy to follow and study with.					
5. I would like to keep using traditional lessons for Chemistry.					
6. The AR app helped me understand periodic elements more clearly.					
7. The AR app helped me remember element details better than the book.					
8.The AR app was more engaging and enjoyable than the traditional lesson.					

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9. The AR app was easy to use and navigate.					
10. I would like to keep using AR apps like Wonder Table for Chemistry.					

Survey Question for College:

Questions:	1	2	3	4	5
1. The traditional lesson helped me understand periodic elements.					
2. The traditional lesson helped me remember the symbols and properties of elements.					
3. The traditional lesson was interesting and engaging.					
4. The traditional lesson was easy to follow and study with.					
5. I would like to keep using traditional lessons for Chemistry.					
6. The AR app helped me understand periodic elements more clearly.					
7. The AR app helped me remember element details better than the book.					
8. The AR app was more engaging and enjoyable than the traditional lesson.					
9. The AR app was easy to use and navigate.					
10. I would like to keep using AR apps like Wonder Table for Chemistry.					

APPENDICES C
USER'S GUIDE

Steps to Run Wonder Table: From Start to Quiz

1. Launch the App
- Locate the Wonder Table icon on your Android device.
- Tap the icon to open the application.
- The app will show a splash screen with the logo and title.

2. Navigate the Home/Start Screen
- Once the app loads, you will see the Start/AR main screen.
- Options typically include:
  - Start/Explore AR – to access the AR periodic table.
  - Quiz – to take the knowledge assessment.
  - About – to provide a step-by-step guide.

3. Starting the AR Experience

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- Tap the Start/Explore AR button.
- The app may request camera permissions. Allow access so the AR can function.
- Scan the AR marker or table image provided by the app. (This triggers the 3D periodic table to appear.)
- The AR view will display interactive elements of the periodic table:
    - Tap any element to view atomic number, symbol, and description.
    - Swipe or rotate the table for different views.

4. Using the AR Features

- Select elements to learn about them in 3D or interactive pop-ups.
- Some elements may have additional animations or explanations.
- Continue exploring until you feel ready for the quiz.

5. Accessing the Quiz

- Return to the Home Screen or select the Quiz option from the AR menu.
- The quiz screen will display difficulty levels (Easy, Hard) if available.
- Tap your desired difficulty level.

6. Taking the Quiz

- Answer each question related to the periodic elements.
    - Questions may include:
        - Identifying elements by symbol or atomic number.
        - Selecting correct element properties.
- Submit each answer to move to the next question.
- After completing all questions, the app will display your score and feedback.

7. Viewing Results

- The results screen may show:
    - Number of correct answers.
    - Percentage score.
- You can restart the quiz or return to the AR exploration.

8. Exiting the App

- Tap the Back button to return to the main screen.
- Close the app using your device’s standard exit method.

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APPENDICES D

DOCUMENTATION

Figure 32 Title Hearing

Figure 32 shows the researchers during the Title Hearing conducted at the CL3 Laboratory of ACLC College of Butuan. The session was facilitated by three panel members, together with the CED focal person and the team's adviser, who evaluated and refined the initial study concept. This stage marked the beginning of the capstone process, where the proposed title was assessed, and recommendations were provided to ensure the clarity and relevance of the research. The image captures the team's preparedness and active engagement during the discussion.

Figure 33. Proposal Defense

Figure 33 Proposal Defense captures the team during the Final Defense in the CL3 Laboratory of ACLC College of Butuan. Present during the evaluation were three panelists, the CED focal person, and the adviser, who reviewed the completed system, research findings, and implementation results. In the

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final evaluation, the group served as the second presenter, yet once again became the first among all presenters to have their capstone fully approved. The image represents the successful culmination of the capstone journey and the validation of their final research output.

Figure 34. Final Defense

Figure 34 captures the team during the Final Defense, held in the CL3 Laboratory of ACLC College of Butuan. In this stage, the group was the 4th presenter, yet once again became the first among all presenters to have their capstone fully defended and approved. Present during the evaluation were three panelists, the CED focal person, and the adviser, who reviewed the completed system, research findings, and implementation results. During the presentation, the researchers showcased their fully developed project, addressed the panel's technical questions, and justified the overall significance and impact of their study. The image represents the successful culmination of their capstone journey and the panel's validation of their final research output.

Figure 35. Data Gathering

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Figure 35 illustrates the process of collecting information from various online platforms to support the development of the Wonder Table application. The researchers used credible internet sources such as academic articles, digital encyclopedias, online chemistry databases, and educational websites to gather accurate scientific data about periodic elements. In addition, Unity documentation, online tutorials, and developer forums were accessed to obtain technical guidance necessary for building and optimizing the AR features of the mobile application. This internet-based data gathering ensured that both the content and technical components of the system were accurate, updated, and reliable.

Figure 36. Revision and Development

Figure 36 illustrates the Revision and Development phase for the Wonder Table: An Android Based Augmented Reality Learning Tool for Periodic Elements capstone project. The image captures the collaborative efforts of the proponents as the team works on their laptops, signifying the intensive work undertaken to refine both the application and the capstone documentation.

Figure 37. Conducting Survey and Interview

Figure 37 illustrates the researchers' conduct of the multi-method evaluation, which included survey, interview, pre-test, and post-test sessions with elementary, high school, and college respondents. This comprehensive data gathering was executed to rigorously assess the Wonder Table application's effectiveness as an AR learning tool. The pre-test established baseline knowledge, while the subsequent post-test measured the gain in understanding after using the AR features. Structured surveys and interviews provided essential data on usability, engagement, and qualitative feedback, ensuring a thorough and well-rounded evaluation of the learning outcomes.

ACKNOWLEDGEMENT

The proponents express their heartfelt gratitude to everyone who helped validate and shape this study. Their advice and assistance were crucial to the team's accomplishment of the project's objectives.

To **Mr. Gerardo S. Carlos**, Capstone Project Adviser, thank you for your guidance, patience, and dedication. Throughout the process, your support and desire to impart your knowledge kept the proponents motivated and focused.

To the Panelists: **Mr. Jamel D. Pandiin, MSIT**; **Mr. Joshua A. Caalim, MSIT**; and the Chairperson during our defense, **Mr. Daryl A. Cabagay, MSIT**, thank you for your time, insightful ideas, and comments, which improved the quality of this work.

To **Mr. Jamel D. Pandiin, MSIT,** and **Mrs. Marjorie C. Centino, MSIT**, Capstone Project instructors, for your assistance in providing the required document formats and for keeping the team on track with reminders about deadlines and duties.

To our family, for your ongoing support and encouragement during our academic journey and the development of this project.

To our friends, for the encouragement and confidence you provided, which motivated us to keep going.

Lastly, the proponents express their heartfelt gratitude to Almighty God for His direction, wisdom, and blessings, which enabled the project's completion.

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APPENDICES E
INFOGRAPHICS

Wonder Table: An Android Based Augmented Reality Learning Tool for Periodic Elements

AUTHORS: BACALING, CORVERA, LOPEZ, ADVISER: GERARDO S. CARLOS JR

INTRODUCTION

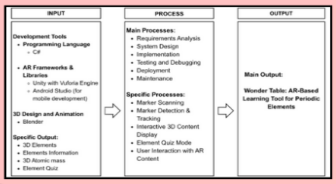
Chemistry's abstract concepts make learning difficult. Augmented Reality improves visualization and engagement. Wonder Table, an Android AR app, presents 3D periodic elements and quizzes to enhance understanding, retention, and student-centered learning.

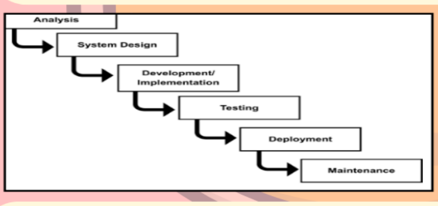
OBJECTIVES

The researcher designed and implemented an accessible, user-friendly Augmented Reality (AR) application. This system developed and presented interactive 3D periodic elements paired with MCQ reinforcement quizzes. Finally, the application's effectiveness was assessed against traditional methods using pre- and post-tests and surveys to measure student learning, retention, motivation, and usability.

PROJECT CONCEPT

The Wonder Table model used C#/Unity, Blender, and periodic data as Input. The Process involved AR scanning and 3D rendering. The Output is a mobile AR tool allowing students to view 3D atomic models, access details, and take quizzes with feedback.



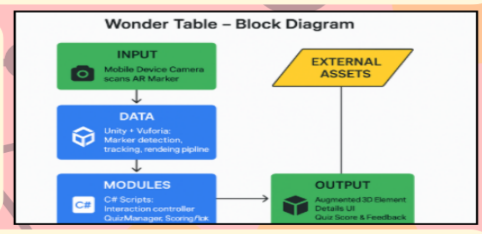


DEVELOPMENT MODEL

The Wonder Table was developed using a standard SDLC, starting with Requirement Analysis. This led to System Design, Development/Implementation, and Testing. The final phases were Deployment and ongoing Maintenance to ensure the AR learning tool remains reliable and functional.

SYSTEM DESIGN

The system design was developed directly from the needs identified during the initial analysis phases. It explicitly outlined the modules created by the proponents, establishing the foundational structure and core functionality of the Wonder Table application. This approach ensures the final AR tool is accurately tailored to meet specific user requirements and learning objectives.



Software Quality Factors	Mean Average	Descriptive Rating
Functionality	4.27	Highly Functional
Reliability	4.18	Reliable
Usability	4.36	Usable
Efficiency	4.35	Efficient
Mean:	4.29	Highly Acceptable

RESULTS & DISCUSSIONS

The system is designed to address the needs identified in the earlier stages. The modules developed by the proponents are clearly outlined in the design, serving as the foundation for the overall structure and functionality of the Wonder Table application.

CONCLUSION

The researcher concluded the Wonder Table AR application successfully met all goals, acting as an effective, accessible, and user-friendly supplementary tool. By integrating 3D elements and quizzes, it measurably improved student learning, retention, motivation, and comprehension over traditional teaching methods.

ACKNOWLEDGEMENT

The proponents expressed heartfelt gratitude to all who validated and shaped the study. They specifically thanked the Adviser (Mr. Carlos) and Panelists for their guidance, and instructors, family, and friends for their support. Final thanks were given to Almighty God.

REFERENCES

Ribič, L., & Devetak, I. (2024). Augmented reality in developing students' understanding of chemistry triplet: A systematic literature review. Chemistry Teacher International. Retrieve from https://doi.org/10.1515/cti-2024-0060

APPENDICES F
GRAMMARLY RESULT

Chapter 1
by ACLC Grammarly

General metrics

13,353	1,828	99	7 min 18 sec	14 min 3 sec
characters	words	sentences	reading time	speaking time

Score

99

This text scores better than 99% of all texts checked by Grammarly

Writing Issues

9	1	8
Issues left	Critical	Advanced

Chapter 2
by ACLC Grammarly

General metrics

18,436	2,401	167	9 min 36 sec	18 min 28 sec
characters	words	sentences	reading time	speaking time

Score

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Writing Issues

11	1	10
Issues left	Critical	Advanced

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Chapter 3

by ACLC Grammarly

General metrics

19,636	2,809	295	11 min 14 sec	21 min 36 sec
characters	words	sentences	reading time	speaking time

Score

99

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Writing Issues

17	5	12
Issues left	Critical	Advanced

Chapter 4

by ACLC Grammarly

General metrics

18,420	3,027	687	12 min 6 sec	23 min 17 sec
characters	words	sentences	reading time	speaking time

Score

99

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Writing Issues

15	6	9
Issues left	Critical	Advanced

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Chapter 5

by ACLC Grammarly

General metrics

14,704	2,024	124	8 min 5 sec	15 min 34 sec
characters	words	sentences	reading time	speaking time

Score

99

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Writing Issues

8	3	5
Issues left	Critical	Advanced

APPENDICES G
TURNITIN RESULT

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4%	2%	1%	2%
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APPENDICES H

HUMAN GRAMMARIAN CERTIFICATE

ACLC College of Butuan
RESEARCH INNOVATION AND EXTENSION DIVISION
Butuan City

CERTIFICATION

This is to certify that the study titled:

" Wonder Table: An Android Based Augmented Reality Learning Tool for Periodic Elements"

with proponent/s:

Bacaling, Bryan Peter P.
Corvera, Bryce A.
Lopez, James Lopez C.

underwent consultation and aligned with the set structural rules that govern the composition of sentences, phrases and words in the English Language at ACLC College of Butuan-Research Productivity Unit (ACLC-RPU).

This certification is issued for whatever legal purpose it may serve best.

Issued this on the 25th day of November 2025 at ACLC College of Butuan, Bayanihan, Butuan City, Philippines.

Validated by:

GABRIEL ADOLFO C. MALBAS, LPT
Designated Grammarian

GABRIEL ADOLFO C. MALBAS, LPT
Director, RIED

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APPENDICES I
CURRICULUM VITAE

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COMPETENCY SYNOPSIS

- A graduate of A.C.L.C College of Butuan Inc, with a Bachelor of Science in Information Technology degree.

PERSONAL PROFILE

Age:	23 years old
Date of Birth:	December 12, 2002
Place of Birth:	Butuan City
Civil Status:	Single
Citizenship:	Filipino
Gender:	Male
Religion:	Roman Catholic
Father's Name:	Peter F. Bacaling
Mother's Name:	Rosalyn P. Bacaling

EDUCATIONAL ATTAINMENT

TERTIARY:
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PERSONAL PROFILE

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Place of Birth:	Butuan City
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Gender:	Male
Religion:	Evangelical Christian
Father's Name:	Ariston T. Corvera
Mother's Name:	Iris J. Corvera

EDUCATIONAL ATTAINMENT

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School

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Butuan City
July 2015 - March 2019

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PERSONAL PROFILE

Age:	21 years old
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Place of Birth:	Butuan City
Civil Status:	Single
Citizenship:	Filipino
Gender:	Male
Religion:	Roman Catholic
Father's Name:	Jimmy M. Lopez
Mother's Name:	Elena C. Lopez

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July 2016 - March 2022

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- School
J.C Aquino Ave, Butuan
July 2010 - March 2016

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