**ARchive: Exploring DYCI ALAB Through Augmented Reality**

A Capstone Project Presented to the Faculty of the

College of Computer Studies

Dr. Yanga’s Colleges, Inc.

by

Cañete, Romce Angelo R

Domingo, Ryan Joseph DC.

Ellorza, Alexa Mae I.

Estanislao, Jerico N.

Salonga, Mark Lester J.

BSIT-3A

May 2025

**CHAPTER I: THE PROBLEM AND ITS BACKGROUND**

**INTRODUCTION**

In recent years, there has been a global trend toward integrating immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) into educational environments. Museums around the world are embracing these innovations to enhance interactivity and provide more engaging learning experiences for visitors. This digital shift reflects a growing demand for technology-driven tools that support experiential and visual learning, particularly among younger, tech-savvy audiences.

Despite this trend, many museums in the Philippines—including those within academic institutions—continue to rely on static, traditional display methods. These outdated approaches, often limited to guided tours and printed descriptions, do not align with the expectations of modern learners and fail to fully capture the attention and curiosity of visitors. The ALAB Museum at Dr. Yanga’s Colleges, Inc. (DYCI) showcases award-winning robotics innovations, yet it faces similar limitations in delivering interactive and immersive experiences.

To address these challenges, the project *ARchive: Exploring DYCI ALAB Through Augmented Reality* aims to modernize the museum experience by implementing mobile-based AR and VR technologies. Specifically, the project seeks to improve interactivity, accessibility, and educational impact through features such as QR code-triggered 3D models, robot animations, a VR tour mode, and an administrator dashboard for content and engagement management.

Aligned with the DYCIAN value of *Magis*—the pursuit of excellence and doing more for the greater good—this project contributes to the institution’s ongoing innovation efforts by transforming static museum displays into dynamic, interactive environments. It offers a scalable, sustainable platform that not only enhances the appreciation of the DYCI Robotics Team’s achievements but also sets a precedent for future technology-integrated educational initiatives

**BACKGROUD OF THE STUDY**

The DYCI Robotics Team has consistently demonstrated innovation and excellence in the field of robotics, earning numerous accolades in both local and international competitions. Their creations are more than mechanical constructs—they represent a seamless integration of science, engineering, and creativity. These award-winning robots are housed in the ALAB Museum at Dr. Yanga’s Colleges, Inc., which serves not only as a repository of technological achievement but also as a vibrant educational hub for students and visitors.

Currently, the museum operates through a traditional exhibit model. During educational visits, guests are allowed to explore the museum freely. At each robot station, a student from the DYCI Robotics Team is assigned as a guide, offering insights into the design, functionality, and competitive background of the robots. When available, these guides also demonstrate the capabilities of interactive robots, providing hands-on experiences for visitors.

This setup offers a personalized approach to learning, enabling guests to gain firsthand knowledge from students who were directly involved in the robots’ development and competition journey. However, while this model is effective in fostering engagement during guided trips, it still relies heavily on manual interaction and physical presence, limiting the museum’s potential to provide scalable, consistent, and immersive educational experiences to a broader audience.

**PROJECT CONTEXT**

The ALAB Museum of Dr. Yanga’s Colleges, Inc. (DYCI) serves as a repository of innovation, showcasing the internationally recognized, award-winning creations of the DYCI Robotics Team. These robots reflect a fusion of engineering excellence and creativity, contributing significantly to both institutional pride and STEM education. Despite the significance of its exhibits, the museum’s traditional presentation methods—such as printed descriptions and student-led tours—have proven insufficient in engaging modern, tech-oriented learners.

While global trends in education and museum curation increasingly embrace immersive technologies, many local institutions, including DYCI, continue to rely on static displays. This creates a gap in delivering meaningful, interactive experiences that foster deeper understanding and sustained visitor interest.

To address these challenges, the project ARchive: Exploring DYCI ALAB Through Augmented Reality introduces a mobile-based application that leverages Augmented Reality (AR) and Virtual Reality (VR). Through QR code scanning, users can access animated 3D robot models, view detailed exhibit information, and explore a virtual version of the museum. This solution aims to modernize the ALAB Museum by transforming it into an engaging and educational digital space aligned with current technological advancements.

**PROJECT PURPOSE**

The purpose of this project is to develop a mobile application for the ALAB Museum that enhances visitor engagement and learning by integrating Augmented Reality (AR) and Virtual Reality (VR) technologies. This application addresses the limitations of traditional static exhibits by providing an interactive and immersive experience that allows users to explore the museum’s award-winning robotics displays in new and meaningful ways.

By transforming physical exhibits into dynamic digital content accessible via QR codes and mobile devices, the project aims to increase accessibility, interactivity, and educational value for visitors. Ultimately, this project seeks to modernize the museum experience, making it more engaging and informative while showcasing the technological achievements of the DYCI Robotics team.

**STATEMENT OF THE PROBLEM**

The ALAB Museum at Dr. Yanga’s Colleges, Inc. serves as a center for innovation and a testament to the excellence of the DYCI Robotics Team. While it offers a rich collection of award-winning robotics exhibits, the current setup remains largely static and dependent on student-led tours. This limits visitor engagement and does not fully align with the expectations of today’s digital-native audience. This study seeks to identify how an augmented reality-based mobile application can effectively address these challenges, specifically:

* How can the current system for guiding visitors in the ALAB Museum be improved to create a more engaging and informative experience?
* In what ways can non-interactive robot exhibits be enhanced through the use of augmented reality to increase visitor interaction and interest?
* How can the application improve accessibility to the museum’s VR content and ensure a more inclusive and immersive experience for all visitors?
* What interactive features can be implemented to go beyond traditional QR code usage and create a richer digital learning environment?
* How do users perceive the functional suitability, performance efficiency, compatibility, reliability, security, maintainability, portability, perceived usefulness, and ease of use of the proposed ALAB Museum Augmented Reality mobile application?

These questions aim to guide the development of a mobile solution that transforms the ALAB Museum into a dynamic, interactive educational space while promoting the accomplishments of the DYCI Robotics Team through meaningful technological integration.

**OBJECTIVES OF THE STUDY**

This study aims to enhance the overall museum experience at Dr. Yanga’s Colleges, Inc. (DYCI) by developing ARchive: Exploring DYCI ALAB Through Augmented Reality, a mobile-based application that integrates Augmented Reality (AR) and Virtual Reality (VR) technologies to improve accessibility, interactivity, and visitor engagement within the ALAB Museum. To achieve this aim, the study pursues the following specific objectives:

* To design and develop a mobile application that utilizes AR and VR technologies in presenting interactive and immersive exhibits of the ALAB Museum.
* To implement a QR code scanning feature that displays animated 3D models, detailed descriptions, and optional voice narrations of robot exhibits.
* To integrate a Virtual Reality walkthrough that allows users to explore the ALAB Museum in a simulated environment.
* To provide an administrator dashboard for efficient management of exhibit data, including QR code generation and 3D model uploads.
* To assess the application’s usability, functionality, performance, and educational effectiveness through user evaluation and feedback.
* To support DYCI’s commitment to academic innovation by offering a modern instructional resource that promotes appreciation of robotics and engineering concepts.

**SCOPE AND LIMITATIONS OF THE PROJECT**

**Scope of the Study**

This study involves the design, development, and deployment of ARchive: Exploring DYCI ALAB Through Augmented Reality, a mobile application aimed at enriching the visitor experience at the ALAB Museum of Dr. Yanga’s Colleges, Inc. through the use of Augmented Reality (AR) and Virtual Reality (VR) technologies. The system includes the following components:

* **Administrator Module (DYCI Robotics Team)**: Allows authorized DYCI robotics personnel to manage robot exhibits, generate and monitor QR codes, and oversee system performance via a comprehensive dashboard. Admins can upload, edit, and delete 3D robot profiles (.glb, .fbx, .blend format), manage metadata, track visitor interaction through analytics, and handle account management with role-based access control.
* **User Module:** Enables visitors to interact with robot exhibits by scanning QR codes. Upon scanning, the app renders 3D AR models and animations of robots, allowing for interactive engagement including basic movement simulations. A voice narration feature plays an audio guide that provides informative commentary about each robot, enhancing understanding and accessibility. Visitors may also access VR mode using a mobile-compatible headset to navigate a virtual representation of the museum. Additionally, visitors can scan special markers to trigger AR videos showcasing the DYCI Robotics Team’s international achievements.

The ARchive app is designed for mobile use, delivering immersive, educational experiences to museum visitors through the combination of visual storytelling and interactive simulation.

**Limitations**

* The application is designed specifically for the ALAB Museum and would require customization for use in other museums or educational settings.
* The app focuses exclusively on robotics exhibits and does not include other types of museum content.
* While both AR and VR are implemented, more advanced technologies such as Mixed Reality (MR) and Artificial Intelligence (AI) are not within the scope of the current version.
* The application does not involve or support the maintenance, repair, or physical management of museum exhibits.
* Physical modifications or upgrades to the museum infrastructure are outside the scope of the project.
* VR mode requires the use of compatible VR Box or phone-based VR viewers but does not provide dedicated VR stations.

**SIGNIFICANCE OF THE STUDY**

In the continuously evolving landscape of education, the integration of immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) has become increasingly relevant in enhancing learning experiences. This capstone project contributes to the advancement of educational technology by demonstrating how these innovations can transform traditional museum exhibits into interactive, engaging, and educational platforms. The study showcases the potential of AR and VR to redefine how educational content is delivered and consumed, particularly in institutional museum settings.

At the institutional level, Dr. Yanga’s Colleges, Inc**.** stands to benefit from the implementation of this project by reinforcing its commitment to innovation and technological excellence. The ARchive application positions DYCI as a progressive educational institution that embraces digital transformation to improve academic delivery and student engagement. By utilizing immersive technology, the institution enhances its reputation as a leader in tech-integrated learning and reinforces its mission to provide dynamic and future-ready education.

For the DYCI Robotics Team, whose international achievements and award-winning creations are the focal point of the ALAB Museum, the project offers a modern and interactive platform to showcase their work. Through AR-enabled 3D models and multimedia content, visitors can engage with the exhibits in a way that highlights the technical sophistication and innovation behind each robot. This not only preserves the legacy of the robotics team but also promotes institutional pride and inspiration for current and prospective students.

At the school level, the application provides educators with a valuable instructional tool that complements conventional teaching methods. It promotes experiential learning, fosters curiosity, and enhances student participation by offering an interactive approach to exploring robotics, engineering, and science concepts. The mobile-based nature of the application ensures accessibility, making it a practical addition to both formal and informal learning environments.

Museum visitors, particularly students and other academic stakeholders, gain a more enriching experience through the interactive features of the application. By scanning QR codes located near each exhibit, users can access 3D representations, view informative content, and interact with the displays in real time. This digital enhancement increases engagement, improves content retention, and transforms passive observation into active exploration.

Lastly, this study holds significance for future researchers who seek to explore the application of immersive technologies in educational contexts. It provides a foundational model for developing AR/VR-integrated systems, addressing key areas such as usability, content management, user interaction, and system scalability. Future studies may expand upon this work to assess long-term impacts on learning outcomes, institutional integration, and the broader adoption of similar technologies in other academic or museum settings.

**DEFINITION OF TERMS**

Below are the key terms used in the research paper, defined for clarity and consistency:

**Augmented Reality (AR)** - A technology that overlays digital content (e.g., 3D models, animations, text) onto the physical world via a mobile device or AR-enabled hardware, enhancing real-world interactions.

**Virtual Reality (VR)** - An immersive technology that simulates a fully digital environment, typically accessed through a headset, allowing users to interact with a virtual space as if they were physically present.

**ALAB Museum -** A museum at Dr. Yanga’s Colleges, Inc. (DYCI) that showcases award-winning robotics innovations created by the DYCI Robotics Team.

**DYCI Robotics Team -** A group of students and faculty at DYCI who design and build competitive robots, earning accolades in local and international competitions.

**QR Code -** A machine-readable matrix barcode used in the ARchive app to trigger AR content (e.g., 3D robot models, animations) when scanned by a mobile device.

**Constructivist Learning Theory -** A pedagogical framework emphasizing active knowledge construction through hands-on interaction with objects or environments (Piaget, 1970; Vygotsky, 1978). In this study, AR enables learners to engage with robotics exhibits to build understanding.

**Free-Choice Learning Theory -** A theory positing that learning in informal settings (e.g., museums) is self-directed and driven by personal interests (Falk & Dierking, 2000). ARchive aligns with this by allowing visitors to explore exhibits at their own pace.

**Interactiveness** - The degree to which users can actively engage with exhibits through AR/VR features (e.g., manipulating 3D models, viewing animations) rather than passively observing static displays.

**Administrator Dashboard -** A web-based interface for DYCI Robotics Team members to manage AR/VR content, generate QR codes, upload 3D models, and track visitor analytics.

**ISO/IEC 25010 -** An international standard for software quality evaluation, assessing factors like usability, performance, and security in the ARchive app.

**Technology Acceptance Model (TAM) -** A framework evaluating user adoption of technology based on perceived usefulness and ease of use (Davis, 1989). Applied to assess visitor acceptance of ARchive.

**Modified Waterfall Model -** A structured software development approach with sequential phases (e.g., requirements, design, testing) and iterative feedback loops, used to build ARchive.

**Firebase -** A cloud platform supporting ARchive’s backend services, including database management (Firestore), user authentication, and file storage.

**Unity 3D -** The game engine used to develop ARchive’s AR/VR features, integrating AR Foundation for cross-platform compatibility (Android/iOS).

**Gamification -** The application of game-design elements (e.g., rewards, interactivity) in non-game contexts, such as ARchive’s engaging exhibit interactions.

**Scalability -** The system’s capacity to handle growing user demand or expanded content without compromising performance.

**Usability -** A measure of how intuitively and efficiently users can navigate ARchive’s features, evaluated via ISO/IEC 25010 and user testing.

**Mixed Reality (MR) -** A hybrid technology blending AR and VR, allowing digital and physical objects to interact in real time (not included in ARchive’s current scope).

**Low-Poly Models -** Simplified 3D models with fewer polygons (<50k triangles) to ensure smooth AR rendering on mobile devices.

**Agile Methodology** - An iterative development approach emphasizing flexibility and user feedback (contrasted with ARchive’s Modified Waterfall approach due to stakeholder constraints).

**CHAPTER II: REVIEW OF RELATED LITERATURE AND STUDIES**

**RELATED LITERATURE**

**Foreign Literature**

Rullyana and Triandari (2024), in the study “Trends and Research Issues of Augmented Reality in Education: A Bibliometric Study,” conducted a large-scale analysis of 1,850 scholarly articles published from 2015 to 2023 to explore global trends in AR-related educational research. The study identified strong and consistent growth in AR adoption, with the United States, China, Spain, Taiwan, and Turkey leading the field. Seven dominant research themes were revealed, particularly in interactive teaching, simulation, and engineering education. The authors also highlighted the influence of key scholars and pointed to rising interest in gamification, collaborative learning, and simulation-based instruction across disciplines.

This literature is relevant to the ARchive project as it confirms the academic and global relevance of AR in educational contexts. It emphasizes that AR is not only a technological trend but a growing pedagogical tool with lasting impact on engagement, accessibility, and knowledge retention. The study’s insights validate ARchive’s educational direction by situating the project within a broader, fast-growing movement in immersive learning technologies. It also supports ARchive’s potential scalability and relevance in addressing both current and future trends in education-focused AR applications.

Shonima P (2024), in the study “Augmented Reality: Transforming Learning Landscapes in Education,” explored the role of AR in enhancing student engagement and learning outcomes through immersive simulations and interactive experiences. The research highlighted how AR allows learners to visualize abstract concepts in 3D, manipulate virtual objects, and collaborate in problem-solving activities. These features were shown to increase motivation, improve academic performance, and foster critical thinking and creativity. The study also emphasized the value of AR in supporting personalized and inclusive learning by addressing diverse educational needs and enabling differentiated instruction.

This literature is relevant to the ARchive project as it reinforces AR’s potential to improve educational delivery through engagement and interactivity—core goals of the system’s integration in the ALAB Museum. Like ARchive, the study advocates for student-centered learning environments that merge theoretical understanding with practical application through digital experiences. The findings support ARchive’s aim of making the museum not just a place for display, but a platform for dynamic, technology-enhanced learning.

Aziz et al. (2024) conducted a study titled “Augmented reality and short videos: transforming museum experiences for visitors” which explored the integration of Augmented Reality (AR) and short video content in enhancing visitor engagement at the Kota Kuala Kedah Museum. The study focused on how these digital tools created interactive and immersive environments, particularly effective in communicating complex historical narratives to younger audiences. By conducting interviews with 15 museum visitors, the researchers found that the use of AR significantly increased interaction, immersion, and educational value within museum exhibits. Visitors reported deeper emotional and intellectual connections to historical content, although some technical issues such as system glitches and usability problems were noted.

This literature is relevant to the current study as it supports the concept of using AR to improve visitor interaction within a museum setting. Similar to the objectives of the ARchive project, Aziz et al.'s findings highlight the effectiveness of AR in delivering educational content in a more engaging and modernized way. Their study reinforces the potential of AR to transform passive museum visits into interactive learning experiences, which aligns with the goal of ARchive in revitalizing the ALAB Museum through immersive and accessible technology.

Rodrigo et al. (2016), in the study “Usability Study of an Augmented Reality Game for Philippine History,” evaluated Igpaw: Intramuros, a mobile AR game designed to teach Philippine history through interactive play at historical landmarks. The study found AR to be highly effective in enhancing knowledge retention and engagement, though it also noted challenges such as user fatigue, AR learning curves, and safety concerns during outdoor navigation.

This literature is relevant to the ARchive project because it demonstrates how AR applications can transform educational experiences in cultural and historical contexts—paralleling the ALAB Museum's robotics showcase. The identified usability issues also inform ARchive's user-centered design approach, particularly in minimizing fatigue and ensuring intuitive interaction within a controlled indoor setting.

Sophia et al. (2024), in the study “The Role of Virtual and Augmented Reality in Enhancing Educational Experiences,” emphasized how AR and VR technologies are reshaping modern learning by creating immersive, engaging, and accessible environments. The study explained how AR overlays digital content onto physical settings, enabling students to interact with diagrams, 3D models, and real-world objects, while VR transports learners into fully simulated experiences. Both technologies were found to enhance comprehension, critical thinking, motivation, and retention. The research also noted their support for differentiated instruction and inclusivity, offering self-paced, learner-centric environments that cater to diverse educational needs.

This literature is relevant to the ARchive project because it validates the use of both AR and VR as tools for active learning and deeper understanding—principles that are central to the system’s goal of revitalizing the ALAB Museum. ARchive’s mobile application and VR station mirror the study’s recommendations for blending immersive digital tools with real-world content to increase accessibility, interaction, and knowledge retention. Sophia’s emphasis on challenges like cost and teacher training also parallels the ARchive team’s focus on sustainable and user-friendly implementation.

**Local Literature**

Panganiban, Menorca, Vinluan, and Rosales (2024), in the study “Virtual and Augmented Reality: Trends, Application, Adoption, and Development in the Philippines,” explored the current state and potential of VR and AR technologies within the Philippine context. The study highlighted how these technologies are increasingly being integrated into education, healthcare, and business sectors, emphasizing their role in enhancing interactivity, accessibility, and user engagement. It also examined challenges such as high implementation costs, limited technical expertise, and infrastructure gaps that hinder widespread adoption.

This literature is relevant to the ARchive project as it highlights the integration of AR in education and other sectors. For ARchive, these insights justify the use of AR to create an immersive museum experience, where students and visitors can interact with DYCI ALAB’s archives, history, and exhibits in a way that is engaging, accessible, and technologically aligned with current trends.

Esteban (2024), in the conference paper *“AR2: Augmented Reality for Enhanced Reading Comprehension,”* describes the design phase of an AR-based intervention (called AR2) aimed at supporting elementary students’ reading comprehension in the Philippine context. The study uses Assemblr Studio to build AR content tied to a short story, structured for collaborative reading. Evaluators in the design stage judged the AR content to be enjoyable, interesting, engaging, and interactive, indicating promise for AR integration in literacy education.

This literature is relevant to the ARchive project as it demonstrates AR’s potential to make educational content interactive and engaging. ARchive applies this principle to a museum-style format, allowing learners and visitors to explore DYCI ALAB’s history and achievements through interactive AR exhibits that simulate real-world experiences in a controlled virtual environment.

**RELATED STUDIES**

**Foreign Studies**

Dela Cruz, Sevilla, San Gabriel, Dela Cruz, and Ella Joyce (2018), in the study “Design and Development of Augmented Reality (AR) Mobile Application for Malolos’ Kameztizuhan,” developed an AR mobile application to simulate, view, and interact with the historical structures of Malolos’ Kameztizuhan. Using Unity3D, SketchUp, and Vuforia, the application allowed users to explore accurate 3D reconstructions of heritage buildings that had been lost or altered. Testing with tourists and local stakeholders yielded highly positive feedback, particularly regarding personalization, navigation, and realism. A pre- and post-test showed a significant increase in user knowledge about the site, from 12.57% to 81.14%, demonstrating the application’s effectiveness in promoting heritage education.

This literature is relevant to the ARchive project as it demonstrates how AR can be used to digitally preserve and present historical and cultural artifacts. ARchive can adopt similar principles to create interactive AR/VR exhibits of DYCI ALAB’s archives and historical milestones, enhancing visitor learning, engagement, and appreciation for institutional heritage.

Asaad (2021), in the article “Virtual Reality and Augmented Reality Technologies: A Closer Look,” reviewed the general applications of VR and AR across different industries. The study outlined how these technologies are becoming widespread in fields such as education, entertainment, and healthcare, highlighting their potential to transform user experiences by making them more interactive and immersive.

This literature is relevant to the ARchive project as it provides foundational knowledge about AR’s applications across fields, particularly in education. By showing AR’s potential to enrich experiences, it strengthens the basis for ARchive’s use of AR in presenting institutional history in an engaging way.

Huang, Zou, Cheng, and Xie (2021), in the study “A Systematic Review of AR and VR Enhanced Language Learning,” analyzed research on the use of AR and VR in language learning. The review found that these technologies can improve learner motivation, interaction, and performance by providing immersive and interactive learning environments.

This literature is relevant to the ARchive project as it highlights AR’s role in enhancing motivation and engagement in educational contexts. ARchive applies these principles to a museum-style platform, where interactive AR/VR exhibits encourage learners and visitors to explore DYCI ALAB’s history, projects, and student achievements actively.

Chen, Wang, Chen, Song, Tang, and Tian (2019), in the article *“An Overview of Augmented Reality Technology,”* provided a broad review of AR’s development, principles, and applications. The paper examined AR’s technical foundation and its applications in areas such as education, industry, and entertainment, noting its rapid growth and potential to transform how users interact with digital and real-world information.

This literature is relevant to the ARchive project as it provides a technical and conceptual grounding for AR, affirming its significance as a transformative technology. ARchive leverages these insights to deliver an interactive and immersive VR/AR museum experience of DYCI ALAB.

Elmqaddem (2019), in the article *“Augmented Reality and Virtual Reality in Education: Myth or Reality?”* investigated the use of immersive technologies in education, questioning whether AR and VR are practical tools or simply trends. The study concluded that while challenges remain, AR and VR can bring meaningful benefits to learning by increasing interactivity, motivation, and knowledge retention.

This literature is relevant to the ARchive project as it confirms the potential of AR in education despite challenges. It situates ARchive within a broader discussion about the practicality of immersive tools, reinforcing that its application in presenting DYCI ALAB is both timely and meaningful.

**Local Studies**

Motea (2024), in the study *“The Rise of an Augmented Nation: A Review of Augmented Reality Research in the Philippines,”* reviewed the growing body of AR-related research within the Philippine context. The paper highlighted how AR has been explored in different sectors, including education, culture, and tourism, while also noting limitations such as fragmented initiatives and the need for stronger local research. The study emphasizes that AR in the Philippines is still in its early stages but shows promise as a tool for innovation and societal advancement.

This literature is relevant to the ARchive project as it situates AR within the Philippine context, including education and cultural preservation. By highlighting opportunities and gaps in local AR initiatives, the study supports ARchive’s role as a virtual museum that showcases DYCI ALAB’s history and achievements in an interactive, accessible format, enhancing visitor engagement and learning.

Pitos (2020), in the study “Android-Based Augmented Reality Tourist Guide Application,” developed an AR mobile application designed to guide tourists by providing digital information and interactive experiences about destinations. The application demonstrated how AR could be integrated into tourism, offering users accessible, location-based information through their smartphones.

This literature is relevant to the ARchive project as it illustrates how AR can enhance cultural and historical experiences. ARchive leverages similar principles to provide a VR/AR museum of DYCI ALAB, offering interactive, location-based exploration of its heritage, archives, and exhibits, creating an engaging and immersive learning experience.

Morales and Regio (2024), in the study “Augmented Reality-Based Learning Aid (AR-BLA) in Enhancing the Grade 7 Students’ Learning Performance in Biology,” applied AR as a tool to support secondary students in understanding biology concepts. The research reported positive effects, showing that AR could increase students’ learning performance by making content more engaging and easier to visualize.

This literature is relevant to the ARchive project as it reinforces AR’s role in education, not just as a supplement but as an effective learning aid. By showing measurable improvements in student performance, it supports ARchive’s goal of using AR to enhance students’ understanding and appreciation of DYCI ALAB*.*

Dela Peña (2025), in the article *“Virtual Reality in Aircraft Maintenance Training: Transforming Student Engagement and Competency Development,”* examines how virtual reality (VR) is applied in technical training for aircraft maintenance. The study highlights how VR environments can enhance student engagement, simulate realistic scenarios, and support development of competencies in a controlled, safe setting.

This literature is relevant to the ARchive project as it demonstrates how immersive technologies like VR can bridge the gap between theoretical knowledge and practical skills. ARchive uses similar immersive principles to recreate DYCI ALAB’s environment and exhibits in a virtual/AR museum, allowing users to interact with and explore historical artifacts and student works safely and engagingly.

Montalbo (2021), in the study “eS2MART Teaching and Learning Material in Chemistry: Enhancing Spatial Skills thru Augmented Reality Technology,” investigated the use of AR as a tool to improve students’ spatial abilities in learning chemistry. The study concluded that AR can enhance visualization and comprehension of abstract concepts, providing an interactive learning experience.

This literature is relevant to the ARchive project as it underscores AR’s strength in improving spatial understanding and visualization. ARchive applies the same principle by using AR to make abstract or historical concepts of DYCI ALAB tangible and interactive for students and visitors.

**SYNTHESIS AND RESEARCH GAP**

The reviewed literature and studies consistently affirm the potential of Augmented Reality (AR) and Virtual Reality (VR) to enhance education, cultural preservation, and visitor engagement. Both foreign and local works highlight how immersive technologies improve motivation, interactivity, knowledge retention, and accessibility across learning contexts. For instance, Rullyana and Triandari (2024), Shonima (2024), and Sophia et al. (2024) demonstrated AR’s global relevance in education, emphasizing its role in interactive learning, gamification, and inclusivity. Similarly, local studies by Panganiban et al. (2024), Esteban (2024), and Morales & Regio (2024) reinforced AR’s promise in the Philippine educational landscape, showcasing its effectiveness in increasing engagement and academic performance.

Parallel to these findings, museum-focused works such as Aziz et al. (2024) and Rodrigo et al. (2016) show that AR can transform static exhibits into dynamic and participatory experiences, while local applications such as Pitos (2020) and Motea (2024) confirm AR’s potential in cultural heritage and tourism. These studies align with the objectives of the ARchive project, which seeks to integrate AR within the DYCI ALAB Museum to create interactive, educational, and immersive experiences for students, faculty, and visitors.

Despite the evident promise of AR, gaps remain in its local implementation and contextual adaptation. Many studies point to challenges such as high implementation costs, technical limitations, and lack of institutional adoption. In the Philippine context, AR initiatives are still fragmented and exploratory, with limited focus on museum-based educational applications. While existing works emphasize AR’s impact on general education and tourism, there is little research that applies AR specifically to institutional museums like DYCI ALAB, which hold both historical and academic significance.

The ARchive project addresses this gap by developing an Android-based AR museum application tailored for the DYCI ALAB Museum. Unlike prior works that are either generic educational tools or tourism-oriented applications, ARchive integrates AR with archival exhibits, robotics showcases, and institutional history. It aims to bridge traditional museum limitations by offering interactive 3D models, AR-guided tours, and multimedia content accessible to both on-site and remote users. In doing so, the project not only contributes to the modernization of DYCI ALAB but also enriches the growing body of research on localized AR applications in Philippine education and cultural heritage.

**CHAPTER III: METHODOLOGY AND SYTEM DESIGN**

**RESEARCH DESIGN**

The research employs a qualitative research design anchored on two established frameworks to guide both the technical development and user acceptance assessment of the ARchive application. This dual-framework approach provides a forward-looking, holistic plan for evaluating the AR application's quality and its potential for successful adoption within the museum environment.

The study utilizes a qualitative research approach that focuses on in-depth understanding of user experiences, technical performance characteristics, and system effectiveness within the museum context. This design allows for comprehensive exploration of user interactions, technical quality attributes, and acceptance factors, ensuring that the developed system meets both functional requirements and user satisfaction criteria. The research framework is structured to accommodate the unique constraints of the ALAB Museum environment while maintaining scientific rigor through systematic observation, expert evaluation, and detailed analysis of user experiences and system performance.

**RESPONDENTS AND SETTNINGS OF THE STUDY**

The research is conducted within the ALAB Museum at Dr. Yanga's Colleges, Inc., which serves as the primary setting for system development, implementation, and evaluation. The museum environment provides a controlled yet realistic context for testing the augmented reality application's effectiveness in enhancing visitor engagement with robotics exhibits.

The study involves multiple stakeholder groups, each playing distinct roles in the research process. Museum visitors constitute the primary respondents for user acceptance evaluation, representing diverse age groups and technological backgrounds to ensure comprehensive assessment of the system's usability and effectiveness. The DYCI Robotics Team serves as content experts and technical consultants, providing specialized knowledge about the robotic exhibits and ensuring content accuracy. Museum administrators and staff participate as system managers and facilitators, offering insights into operational requirements and implementation challenges. This multi-stakeholder approach ensures that the research captures perspectives from all relevant user groups and addresses the complex dynamics of museum technology integration.

**DATA GATHERING PROCEDURE**

The research outlines a systematic set of qualitative data gathering methods to be implemented once a functional prototype is ready for evaluation. These methods are designed to capture in-depth insights into user experiences, technical performance, and system effectiveness within the museum environment.

Expert reviews constitute the primary evaluation method through systematic assessment by technical specialists and domain experts using detailed evaluation criteria aligned with ISO/IEC 25010 quality characteristics. These reviews provide comprehensive technical validation and identify areas for system improvement. Usability observation protocols capture detailed user behavior and interaction patterns through direct observation, providing rich insights into actual system usage, user challenges, and successful interaction flows.

User interviews and focus group discussions are conducted following visitor interactions with the ARchive system to gather detailed feedback about perceived usefulness, ease of use, and overall experience. These qualitative methods allow for exploration of user motivations, preferences, and suggestions for system enhancement. Additionally, system interaction logs provide contextual data to support qualitative observations, helping researchers understand usage patterns and identify critical interaction points.

Content analysis of user feedback, expert evaluations, and observational data ensures systematic interpretation of findings. This combination of expert reviews, observational studies, interviews, and content analysis provides comprehensive understanding of the system's impact on museum visitor experience and learning outcomes through detailed qualitative insights.

**STATISTICAL TREATMENT OF DATA AND DATA ANALYSIS**

The data collected through the Google Forms survey and interviews were analyzed using **descriptive statistics** such as frequency, percentage, mean, and standard deviation. Demographic information (e.g., age, gender, role in DYCI) was summarized through frequency and percentage, while evaluation items were measured using a **five-point Likert scale**. Weighted means and standard deviations were computed and interpreted to determine the level of acceptance of the system.

Open-ended survey items and interview responses were examined through **thematic analysis** to identify common issues, challenges, and suggestions for improvement. By combining quantitative results with qualitative feedback, a comprehensive assessment of the system’s usability, functionality, and user satisfaction was achieved.

**PROJECT DEVELOPMENT MODEL**

To develop ARchive: Exploring DYCI ALAB Through Augmented Reality, the research team adopted a Modified Waterfall Software Development Life Cycle (SDLC) model. This approach was specifically chosen to address the unique constraints of the ALAB Museum at Dr. Yanga's Colleges, Inc., where stakeholder availability, particularly from the DYCI Robotics Team, was limited, making a fully Agile approach impractical. The Modified Waterfall model provides the structured planning benefits of traditional waterfall methodology while incorporating feedback loops and iterative refinements that are essential for developing an innovative augmented reality solution.

Requirements Gathering

Verification and Validation

Data Analysis and Design

Verification and Validation

Coding and Development

Verification and Validation

Testing and Evaluation

Verification and Validation

Implementation

Verification and Validation

Operation and Maintenance

Verification and Validation

The requirements gathering process involved conducting a structured interview with the head of the DYCI Robotics Team to obtain comprehensive information about the ALAB museum, its educational objectives, existing infrastructure, and visitor demographics. The functional requirements identified included QR code scanning capability for artifact identification, augmented reality content visualization for museum artifacts, interactive user interface for content navigation, multi-media content delivery encompassing 3D models, videos, text, and audio, user progress tracking and engagement analytics, offline content accessibility for limited connectivity scenarios, and multi-language support for diverse visitor demographics. Non-functional requirements encompassed hardware compatibility with existing museum infrastructure, response time under 3 seconds for AR content loading, system availability of 99% during museum operating hours, intuitive user interface requiring minimal learning curve, scalability to handle peak visitor loads, security measures for content protection and user privacy, and accessibility compliance for users with disabilities.

The system architecture was designed using a modular approach with clear separation between the AR visualization layer, content management system, and user interface components. A client-server architecture was selected to enable centralized content management while supporting offline functionality through local caching mechanisms. The database schema was structured to accommodate artifact metadata, multimedia content references, user interaction logs, and analytics data, with a relational database model chosen to ensure data integrity and support complex queries for content retrieval and user behavior analysis. The UI design process involved creating wireframes and prototypes based on user-centered design principles, with interface layouts optimized for mobile devices and considerations for varying lighting conditions in museum environments. Navigation patterns were designed to be intuitive for users of different age groups and technical proficiency levels. System workflows were mapped out to define the user journey from QR code scanning to AR content consumption, with integration points with existing museum systems identified and data flow diagrams created to illustrate information processing throughout the system.

The development process utilized Unity 3D with C# to implement core augmented reality (AR) functionality and support cross-platform deployment, leveraging ARCore for Android and ARKit for iOS to handle platform-specific AR features. The admin web-based application was built using React.js, enabling a responsive and modular user interface, while Node.js with the Express framework was used to develop backend APIs for handling data and server-side logic. Firebase Cloud Storage was integrated for managing multimedia content and real-time data synchronization. Visual Studio was used for Unity development, and Visual Studio Code (VS Code) was employed for backend and frontend development. Version control was maintained using Git and GitHub to enable collaborative work. The overall programming approach emphasized modularity and a clear separation of concerns, ensuring the system remained maintainable, scalable, and flexible for future feature integration.

The testing phase encompassed multiple levels of validation to ensure system reliability and user satisfaction. Unit testing involved testing individual components and functions in isolation to verify correct behavior, with automated unit tests implemented for critical system functions including QR code processing, database operations, and AR content rendering algorithms. Integration testing focused on validating system components working together to ensure proper communication between the mobile application, backend services, and database systems, with API endpoints validated for correct data exchange and error handling. User Acceptance Testing (UAT) involved comprehensive testing sessions with museum staff and visitor volunteers, including test scenarios covering typical visitor workflows, edge cases, and accessibility requirements, with feedback collected through structured surveys and observational studies to validate system usability and educational effectiveness. Additional testing included performance and compatibility testing across different mobile devices and operating system versions to ensure consistent performance, along with load testing to validate system behavior under peak usage conditions expected during busy museum periods.

The ARchive application was deployed using Firebase as the primary cloud platform for backend services, hosting, and content management to ensure scalability and reliability. The mobile application was distributed through official app stores including Google Play Store and Apple App Store for public access, while the admin web-based application was deployed using Firebase Hosting for seamless integration with the backend services. Firebase's real-time database and cloud storage capabilities provided efficient content delivery and data synchronization across all system components. On-site network infrastructure was configured to support high-bandwidth content delivery within the museum premises, leveraging Firebase's global content delivery network to optimize response times for AR content loading. The deployment process included comprehensive system configuration reviews and deployment checklists to ensure all components were properly installed and functional before full-scale implementation.

The maintenance phase established a comprehensive framework for sustained system operation and continuous improvement. A scheduled maintenance program was implemented including monthly system health checks, quarterly security updates, and bi-annual feature enhancements based on user feedback and evolving educational needs. A ticketing system was established for issue tracking and resolution, with priority levels defined based on impact on user experience and system functionality, ensuring that critical issues affecting AR functionality receive immediate attention while enhancement requests are evaluated and scheduled for future releases. The system architecture was designed with horizontal scaling capabilities to accommodate growing user bases and expanding content libraries, with database optimization strategies and content delivery network integration planned for future implementation as usage increases. This maintenance approach ensures long-term system viability and alignment with changing museum needs and technological advancements.

**REQUIREMENTS ANALYSIS**

**Hardware Requirements**

**For Development:**

|  |  |  |
| --- | --- | --- |
| **Component** | **Minimum Specifications** | **Recommended Specifications** |
| **Developer Workstation** | **Intel Core i5 / AMD Ryzen 5** | **Intel Core i7 / AMD Ryzen 7** |
| **RAM** | **8GB DDR4** | **16GB DDR4 or higher** |
| **Storage** | **256GB SSD** | **512GB NVMe SSD or higher** |
| **GPU** | **NVIDIA GTX 1050 / AMD RX 560** | **NVIDIA RTX 2060 / AMD RX 5700** |
| **Display** | **1080p (1920x1080)** | **1440p (2560x1440) or 4K** |
| **VR Headset (Testing)** | **VR Box** | **VR Box** |

**For Deployment (Visitors):**

|  |  |  |
| --- | --- | --- |
| **Component** | **Minimum Specifications** | **Recommended Specifications** |
| **Visitor Smartphones** | **Android 8.0 (Oreo) / iOS 12** | **Android 10 / iOS 15 or newer** |
| **Processor (Mobile)** | **Snapdragon 660 / Apple A10** | **Snapdragon 855+ / Apple A14 Bionic** |
| **RAM (Mobile)** | **3GB** | **6GB or higher** |
| **ARCore/ARKit Support** | **Required for AR features** | **Optimized for latest versions** |

**For Deployment (Admin Application):**

|  |  |  |
| --- | --- | --- |
| **Component** | **Minimum Specifications** | **Recommended Specifications** |
| **CPU** | **4-core processor (e.g., Intel i5 or Ryzen 3)** | **4-core processor (e.g., Intel i5 or Ryzen 3)** |
| **RAM** | **8GB** | **16GB or higher** |
| **Storage** | **100GB SSD** | **512GB+ NVMe SSD for faster performance** |

**Software Requirements**

**Development Tools:**

|  |  |  |
| --- | --- | --- |
| **Category** | **Software/Tools** | **Purpose** |
| **Game Engine** | **Unity 2022 LTS (with AR Foundation)** | **AR/VR app development** |
| **3D Modeling** | **Blender, Autodesk Maya** | **Robot 3D model creation** |
| **Programming** | **C# (Unity), JavaScript (Firebase)** | **App logic & backend** |
| **Version Control** | **Git, GitHub/GitLab** | **Code management** |
| **Backend Services** | **Firebase (Firestore, Authentication, Cloud Storage)** | **Database, user auth, file hosting** |
| **UI/UX Design** | **Adobe XD, Figma** | **Interface prototyping** |
| **Testing** | **Unity Test Framework, Postman** | **QA & API testing** |

**Deployment and Runtime Requirements:**

|  |  |
| --- | --- |
| **Platform** | **Requirements** |
| **Mobile OS** | **Android 8.0+ (ARCore support) iOS 12+ (ARKit support)** |
| **AR Libraries** | **ARCore (Android) ARKit (iOS)** |
| **VR Runtime** | **VR Box** |
| **Backend Hosting** | **Firebase Hosting** |
| **QR Code Scanner** | **ZXing.Net (Unity plugin)** |

**Network Infrastructure:**

|  |  |
| --- | --- |
| **Requirement** | **Specification** |
| **Internet Connection (Museum)** | **Stable WiFi (5GHz preferred) Minimum 10Mbps upload/download** |
| **Cloud Storage** | **Firebase Storage** |
| **Database** | **Firebase Firestore (NoSQL) (For admin panel: MySQL if self-hosted)** |
| **Security** | **HTTPS encryption Firebase Authentication (Email/Google login for admins)** |

**Functional Requirements:**

|  |  |
| --- | --- |
| **Requirement** | **Description** |
| Code Scanning | The system shall identify and access specific exhibits through QR codes placed in the museum. |
| AR Visualization | The system shall display 3D models, animations, and augmented content for robotics exhibits. |
| Interactive User Interface | Allow users to navigate and interact with AR content intuitively. |
| Multimedia Delivery | Present text, images, audio narration, and videos related to each exhibit. |
| User Progress Tracking | Record user interactions for analytics and insights. |
| Offline Content Accessibility | Provide access to selected content even without internet connection. |
| Administrative Dashboard | Enable administrators to manage exhibits, generate QR codes, upload content, and monitor analytics. |

**Non-Functional Requirements:**

|  |  |
| --- | --- |
| **Requirement** | **Description** |
| Hardware Compatibility | The system shall run on Android smartphones that support ARCore. |
| Performance | The system shall load augmented content within 3 seconds under standard conditions. |
| Availability | The system shall maintain 99% uptime during museum operating hours to ensure reliability. |
| Usability | The system shall offer an intuitive interface that requires minimal learning effort for both visitors and administrators. |
| |  | | --- | | Scalability |  |  | | --- | |  | | |  | | --- | | The system shall support future expansion of exhibits, multimedia content, and user load without major redesign. |  |  | | --- | |  | |
| Maintainability | The system shall support easy updates, bug fixes, and feature enhancements with minimal downtime. |
| Accessibility | The system shall comply with accessibility guidelines, including features such as text-to-speech and high-contrast UI. |

**TECHNICAL BACKGROUND**

The proposed system, *ARchive: Exploring DYCI ALAB through Augmented Reality*, is built using a combination of programming languages, frameworks, database technologies, and cloud services designed to support AR/VR functionality, scalability, and cross-platform deployment. The selection of these technologies ensures an efficient, reliable, and user-friendly solution for both visitors and administrators of the ALAB Museum.

**Programming Languages:**

* C# – Used as the primary language in Unity for implementing AR/VR features, user interactions, and 3D model integration.
* JavaScript (Node.js) – Applied for backend services, API development, and server-side logic in the administrator dashboard.

**Frameworks and Game Engine:**

* **Unity 2022 LTS** – Serves as the core development platform for building AR and VR experiences. Unity supports cross-platform deployment, ensuring compatibility with both Android and iOS devices.
* **AR Foundation** – A Unity framework enabling the integration of ARCore (Android) and ARKit (iOS), providing seamless AR functionality across mobile devices.
* **React.js** – Used to develop the administrator dashboard, offering a responsive and modular web interface for managing content, generating QR codes, and analyzing visitor data.

**Database Technologies and Cloud Services:**

* **Firebase Firestore (NoSQL Database) –** Stores exhibit metadata, user interaction logs, and system configurations, chosen for its scalability, real-time synchronization, and ease of integration with mobile applications.
* **Firebase Cloud Storage –** Manages multimedia assets such as 3D robot models, images, and audio narrations.
* **Firebase Authentication –** Provides secure login and role-based access for administrators.

**APIs and Libraries:**

* **ZXing.Net** – A Unity plugin for QR code scanning, enabling visitors to access AR content by scanning codes placed near museum exhibits.
* **Unity Test Framework & Postman** – Used during testing to validate AR functionality, API integration, and system reliability.

**Development and Collaboration Tools:**

* **Blender & Autodesk Maya –** For creating and optimizing 3D robot models in low-poly format to ensure smooth rendering on mobile devices.
* **Adobe XD & Figma** – Used in the UI/UX design phase to create wireframes and prototypes, ensuring intuitive navigation and accessibility.
* **Git & GitHub –** Employed for version control and collaborative development, allowing efficient code management and team collaboration.

**Platforms and Deployment:**

* **Mobile Platforms:** Android 8.0+ (with ARCore) and iOS 12+ (with ARKit).
* **Cloud Hosting**: Firebase Hosting ensures reliable content delivery and backend performance.
* **VR Mode:** Compatible with phone-based VR headsets such as VR Box, providing an immersive museum experience without requiring expensive dedicated hardware.

**CONCEPTUAL FRAMEWORK**

**User Requirements:**

* Target audience personas
* Learning objectives (e.g., increasing knowledge of robotics or museum history)

**Technical Resources:**

* Specific AR/VR frameworks
* Mobile platforms
* Mobile platforms

**Content Assets:**

* Types of 3D models
* Multimedia formats

**Development Lifecycle Using Modified Waterfall Model**

**Phase 1: Requirements Analysis and Planning -** Conducted surveys, interviews, and observations to identify system needs.

**Phase 2: System Design -** Created UI/UX wireframes and database structure based on user requirements.

**Phase 3: Implementation (Backend and Frontend) -** Developed backend (Firebase) and frontend (mobile app and admin panel).

**ARchive: Exploring DYCI ALAB Through Augmented Reality**

**INPUT**

**PROCESS**

**OUTPUT**

**System Data:**

* QR code formats and how they link to content
* Configurable robot attributes

User behavior tracking methods

**Phase 4: Testing and Integration -** Performed module and system testing; resolved issues and refined features.

**Phase 5: Deployment -** Launched the system with role-specific access and conducted user training.

**Phase 6: Maintenance** - Collected feedback and applied updates for system improvement.

**FEEDBACK**

System Performance

Administrative Review

User Feedback

ARchive mobile application adopts an enhanced Input–Process–Output (IPO) framework with a feedback mechanism to explain the functionality and impact of the ARchive mobile application in the context of the DYCI ALAB Museum. The input phase comprises several critical components. These include user requirements, such as visitor needs for interactive learning, accessibility considerations, and educational objectives. Technical resources play a key role, involving AR/VR-capable mobile devices, development tools like Unity and AR Foundation, and cloud infrastructure for data storage and synchronization. Content assets are also integral inputs, encompassing 3D robot models in .glb format, multimedia elements, animations, descriptive metadata, and audio narration. In addition, system data such as QR codes, user analytics, and robot configurations are used to guide and personalize the experience. Administrative input via a web-based dashboard allows for content management, QR code generation, system configuration, and user permission settings.

In the process phase, the ARchive mobile application was developed using a modified waterfall model to ensure systematic progress across all stages. It began with requirements analysis and planning, interviews, and observations helped identify the needs of users and system goals. This informed the system design phase, which produced UI/UX wireframes and a database structure based on defined user requirements. The implementation phase followed, involving the development of a Firebase backend for data handling and a mobile frontend alongside an admin panel for system control. The application underwent rigorous testing and integration to resolve functional issues and enhance performance. Once stable, the system was deployed with role-based access, allowing users to interact through the mobile app and enabling administrators to manage content. Finally, a maintenance phase was established to collect user feedback, apply updates, and ensure the system continues to meet educational objectives and operational efficiency.

The output is a rich, technology-enhanced museum experience that transforms traditional exhibit viewing into an engaging, self-directed educational journey. Visitors gain deeper insights into each robot’s design and functionality, leading to improved learning outcomes and greater appreciation for DYCI Robotics' achievements. The system promotes accessibility, encourages interaction, and increases user satisfaction. Additionally, it provides administrators with a scalable, efficient content management platform and real-time analytics, helping guide future improvements and exhibit planning. Overall, the ARchive system elevates the museum’s value as both a physical and digital educational space.

A feedback mechanism is embedded in the system to ensure ongoing refinement and responsiveness. Visitor feedback—such as feature requests, usability issues, and satisfaction ratings—is gathered through in-app surveys and analytics. System performance data, including error logs and usage statistics, are used to optimize application performance and user flow. Administrative reviews evaluate the effectiveness of content, operational efficiency, and overall system impact. This feedback is continuously looped back into the input and process phases to guide updates, fix issues, and align the app with user expectations and institutional goals. Through this iterative approach, the ARchive application remains dynamic, educational, and future-ready.

A diagram of a system

AI-generated content may be incorrect.**DATA FLOW DIAGRAM**

The flow of data within the ARchive application, as illustrated in the Data Flow Diagram, centers on the ARchive Mobile Application (Process 0.0), which orchestrates interactions between Museum Visitors, System Administrators, and external data storage services. Museum Visitors engage with the system by scanning QR codes and interacting with augmented and virtual reality content, receiving corresponding AR content and 3D models in real time. Meanwhile, System Administrators manage robot and exhibit data, upload multimedia content, and retrieve both analytics reports and audit logs for system monitoring and decision-making. The application communicates with Firebase Storage for cloud-based media queries, file synchronization, and data backup. Internally, five dedicated data stores support operational functionality: D1 stores robot and exhibit details; D2 manages QR code data and content associations; D3 logs user sessions and interaction analytics; D4 maintains media file references and synchronizes with Firebase; and D5 archives administrative records and audit logs. This structured data flow reinforces the system’s ability to handle simultaneous user sessions, ensure data integrity, and deliver immersive AR experiences effectively within the museum environment.

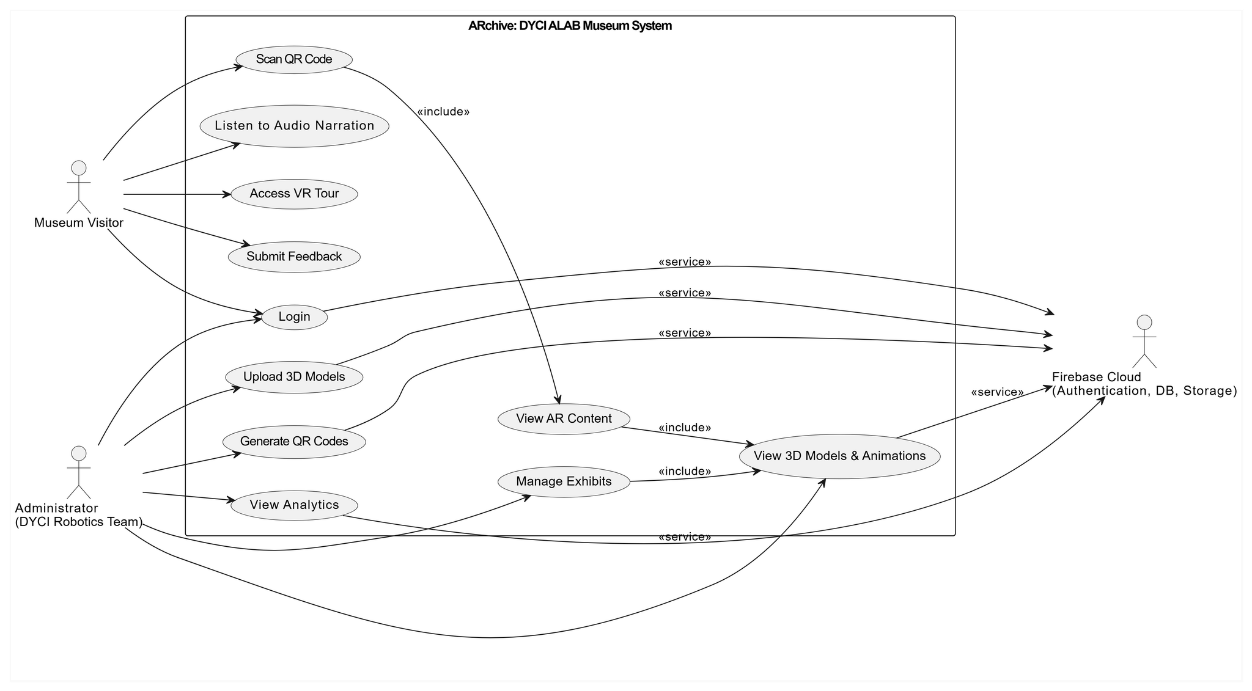
A diagram of a computer

AI-generated content may be incorrect.**ENTITIY RELATIONSHIP DIAGRAM (ERD)**

The Entity Relationship Diagram (ERD) developed for *ARchive: Exploring DYCI ALAB Through Augmented Reality* outlines a structured system for managing interactive robotic exhibits. At its core, the ROBOT entity centralizes essential data and links to related entities that support exhibit presentation, visitor interaction, and system administration. EXHIBIT entities track the physical deployment of robots and are linked one-to-one with QR\_CODE entities, enabling mobile access and usage tracking. Visitor interactions are captured through the USER\_SESSION entity, which logs session durations, accessed features, and device information. Multimedia content is managed by the MEDIA\_FILE entity, which organizes and delivers robot-related media through cloud services. The ANALYTICS entity compiles engagement metrics to support data-driven optimization of exhibits.

Administrative roles and activities are handled through the ADMINISTRATOR and AUDIT\_LOG entities, ensuring secure access control and accountability through detailed action logging. The data flow begins with robot registration, exhibit setup, and QR code generation, followed by visitor engagement and content access, culminating in real-time analytics and logged administrative actions. This ERD provides a robust foundation for ARchive’s goal of enhancing visitor experience and exhibit management through augmented reality and intelligent data integration.

**USE CASE DIAGRAM**

****

.

The diagram represents the **ARchive: DYCI ALAB Museum System**, showing how different users interact with the system and the services provided through Firebase Cloud. The system has two main actors:

1. **Museum Visitor**

Museum visitors are the primary users of the system who can interact with the AR/VR content to enhance their museum experience. Their main use cases include:

* **Scan QR Code** – Visitor Scan QR codes placed near exhibits to trigger AR content.
* **Listen to Narration** – They can listen to supplementary audio descriptions of exhibits,
* **Access VR Tour** – They access a virtual tour of the museum, especially useful for remote or immersive experiences.
* **Submit Feedback** – Visitors can provide feedback about their experience.
* Login – Visitors may log in for personalized experience or to save progress.
* **View AR Content** – Central feature where visitors see augmented reality content tied to exhibits.

1. **Administrator (DYCI Robotics Team)**

Administrators are responsible for maintaining and updating the system. Their use cases include:

* **Login** – Secure access for system management.
* **Upload 3D Models** – Adding new 3D exhibit content into the system.
* **Generate QR Codes** – Creating QR codes that link to AR/VR content for museum displays.
* **View Analytics** – Monitoring visitor interactions and system usage for insights.
* **Manage Exhibits** – Organizing and updating museum exhibits in the digital system.

1. **External System: Firebase Cloud (Authentication, DB, Storage)**

Firebase Cloud acts as a supporting service for:

* **Authentication** – Secure login for both visitors and administrators.
* **Database Management** – Storing user data, feedback, and analytics.
* **Storage** – Hosting 3D models, animations, and other multimedia files.

**Key Relationships**

* **«include»** – Indicates that a use case is always part of another. For example:
  + Scan QR Code includes View AR Content.
  + View AR Content includes View 3D Models & Animations.
  + Manage Exhibits includes View 3D Models & Animations.
* **«service»** – Shows system dependencies on Firebase Cloud for login, storage, and data retrieval.

**SYSTEM DESIGN AND FEATURES**

This section presents the design of the ARchive system, highlighting its screen layouts, modules, and core features that collectively address the needs of the DYCI ALAB museum.

1. **Screen Layouts**

The system consists of a simple and intuitive interface for both users and administrators. Sample layouts include:

* **Home Screen** – Provides access to scanning QR codes, viewing AR content, and navigating the museum experience.
* **Exhibit Display Screen** – Shows AR visualizations, 3D models, and multimedia information when a QR code is scanned.
* **Admin Dashboard** – Allows Museum staff to upload content, generate QR codes, and manage exhibits.
* **Feedback Screen** – Provides users with the option to submit suggestions or report issues.

1. **System Modules**

**The system is divided into the following interconnected modules:**

* **QR Code Module –** Handles the generation and scanning of QR codes for exhibit access.
* **AR Visualization Module –** Renders 3D models, animations, and overlay information through ARCore technology.
* **Content Management Module –** Enables administrators to add, update, or delete exhibit information.
* **Multimedia Module –** Delivers text, images, audio narration, and videos related to each exhibit.
* **Feedback and Analytics Module –** Records user responses and generates reports for system evaluation.

1. **Key Features**

**The ARchive system incorporates the following features to enhance museum learning:**

* **Augmented Reality Integration –** Provides interactive AR experiences for better engagement with exhibits.
* **Offline Accessibility –** Ensures that users can access basic exhibit details without internet connection.
* **Multi-Language Support –** Offers content in different languages for diverse visitors.
* **Navigation Support –** Guides users in exploring exhibits efficiently.
* **Admin Tools –** Equips staff with functions for exhibit management and analytics reporting.

These design elements and features collectively ensure that the ARchive system enhances the museum experience, promotes interactive learning, and addresses the limitations of traditional static exhibits.

**TESTING PROCEDURES**

This section outlines the methods applied to evaluate the functionality, reliability, and usability of the ARchive system. Different levels of testing were conducted to ensure that the system performed as expected and met the requirements of both users and administrators.

1. **Unit Testing**

Each individual module of the system was tested in isolation to verify that it performed its intended function correctly. Core modules such as QR code scanning, AR visualization, and content management were validated for accuracy and stability.

1. **Integration Testing**

After individual modules were verified, integration testing was conducted to ensure that all components worked together seamlessly. This involved testing the connection between the QR scanning feature and AR content display, as well as the interaction between the administrative dashboard and the mobile application.

1. **User Acceptance Testing (UAT)**

To confirm that the system met user requirements, a User Acceptance Testing phase was carried out with a group of respondents representing the intended end-users, including students, faculty, and administrators. Participants evaluated the system’s usability, accessibility, and overall effectiveness through guided use and structured feedback. Their insights were used to validate system performance and identify areas for refinement.

**IMPLEMENTATION PLAN**

The ARchive system will be introduced through a structured implementation process to ensure smooth adoption by the intended users.

**System Installation**

* The application will be installed on ARCore-compatible Android devices. QR codes will be deployed across the DYCI ALAB museum to provide access to AR content when scanned by users.

**User Orientation and Training**

* End-users, including students, faculty, and visitors, will be given short orientation sessions on how to use the app. Training for administrators will focus on managing exhibits, uploading multimedia content, and generating QR codes.

**Phased Deployment**

* **Pilot Rollout** – The system will first be deployed to a small test group for initial feedback.
* **General Rollout** – Full deployment across all intended users of DYCI ALAB.
* **Post-Deployment Review** – Collection of user feedback and performance evaluation for future enhancements.

**Maintenance and Support**

* Regular updates and troubleshooting will be provided to ensure continued system performance. Feedback mechanisms will be established to gather user suggestions and report issues for ongoing improvement.

**ETHICAL CONSIDERTIONS**

The study ensured that all ethical standards in research were observed. Participation in the survey and interviews was voluntary, and respondents were asked to provide informed consent before taking part in the study. The purpose of the research was clearly explained, and participants were made aware that their responses would be used exclusively for academic purposes.

To protect the privacy of the respondents, confidentiality and anonymity were strictly maintained. No personal identifiers were collected beyond general demographic information, and all responses were stored securely. The researchers guaranteed that the information would not be shared with unauthorized parties.

Furthermore, the study respected the rights and welfare of the participants by ensuring that no form of harm, bias, or misrepresentation occurred during the research process. All data were handled responsibly and ethically, aligning with institutional research guidelines.