

## Development of Glide Path Simulation as an Interactive Learning Media

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### ABSTRACT

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Glide Path equipment plays a critical role in providing vertical guidance approach and landing procedures. However, learning activities related to operations in aviation vocational education are often constrained by limited laboratory facilities, restricted use of sensitive navigation equipment, and the lack of interactive learning media capable of effectively visualizing complex operations. These limitations reduce opportunities for cadets to repeatedly explore operations and strengthen their conceptual understanding. This study aimed to design an interactive Glide Path Simulation application using Smart Apps Creator (SAAC) for learning at Makassar Aviation Polytechnic. The study employed a Design and Development (D&D) research approach consisting of needs analysis, application design development, and functional testing. Data were collected through observation, direct literature review, and application testing. Functional evaluation was conducted using the Black-box Testing method to verify the operational performance of each application. The developed application integrates instructional text, technical illustration videos, audio narration, and interactive simulations within a structured multimedia environment. The application presents learning materials on the Instrument Landing System (ILS), Glide Path components, operational procedures, and system parameters through an interactive interface that supports offline operation on desktop and Android. Functional testing demonstrated that all application features operated according to predetermined design specifications without significant operational errors, indicating that the application is technically feasible as an interactive learning medium. This study supports the development of multimedia-based instructional media for aviation vocational education by providing an accessible, offline, and no-code learning solution that visualizes complex navigation concepts and promotes independent learning for Glide Path operational training.

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## INTRODUCTION

Air transportation has become one of the most important transportation sectors supporting global mobility, economic activities, tourism, logistics, and international connectivity. The increasing demand for safe, efficient, and reliable aviation services requires continuous improvement in aviation technology, infrastructure, and human resources. In this context, aviation education institutions play a significant role in preparing competent personnel capable of operating and maintaining aviation systems according to international standards.

The development of aviation technology has significantly influenced navigation systems used in modern airports. Aircraft navigation systems continue to evolve to improve operational safety during takeoff, en-route flight, and landing procedures. Landing procedures are considered one of the most critical phases of flight operations because pilots must maintain aircraft stability and precision while approaching the runway. Therefore, reliable navigation aids are required to support pilots during landing operations, especially under poor weather conditions or limited visibility.

One of the most widely used landing navigation systems is the Instrument Landing System (ILS). ILS is a radio navigation system that provides horizontal and vertical guidance to aircraft approaching the runway. The system enables aircraft to perform precise approaches and safe landings even when pilots cannot visually identify runway conditions clearly. ILS consists of several components, namely localizer, glide path, and marker beacon. Each component has different operational functions but works together to provide accurate navigation guidance.

The advancement of science and technology in the aviation sector has significantly improved the quality of air transportation services, particularly in terms of aviation safety and operational efficiency. Aviation safety remains the primary priority in the aviation industry because every flight operation requires highly reliable navigation systems to ensure aircraft can operate safely under various weather conditions. One of the important supporting systems in aviation navigation is the Instrument Landing System (ILS), which functions to assist pilots during landing procedures through precise horizontal and vertical guidance.

The Instrument Landing System consists of several supporting components, including localizer, marker beacon, and glide path. Glide path is a navigation aid that provides vertical guidance to aircraft during landing approach procedures. This equipment helps pilots maintain the correct descent angle, generally around  $3^\circ$ , so that the aircraft can reach the touchdown point safely and accurately. Therefore, understanding the operation and working principles of glide path equipment becomes an essential competency for aviation cadets, especially students in the Air Navigation Technology Study Program at Makassar Aviation Polytechnic.

Several previous studies have demonstrated that interactive and simulation-based learning media provide significant benefits in improving students' understanding, engagement, and motivation, particularly in technical and vocational education fields that require strong practical competencies. The integration of digital simulation technology into the learning process enables students to visualize complex systems, perform procedural practices repeatedly, and gain experiential learning without being constrained by the availability of physical equipment or laboratory schedules. In aviation education and other engineering-related disciplines, simulation-based learning has become increasingly important because many operational systems involve complex mechanisms, high operational risks, and expensive equipment that cannot always be directly accessed by students during training sessions.

Ariyanti (2019) conducted a study on the development of an Instrument Landing System (ILS) calibration simulation using Adobe Flash as an interactive learning medium for aviation cadets. The study aimed to address difficulties faced by cadets in understanding the operational principles and calibration procedures of ILS equipment, particularly due to limited direct access to laboratory facilities and navigation devices. Through the developed simulation, cadets were able to visualize the calibration process, understand signal transmission mechanisms, and observe the relationship between system parameters and operational outputs in a more interactive manner. The results of the study indicated that the use of simulation media significantly improved cadets' conceptual understanding of aviation navigation systems compared to conventional instructional methods. In addition, the interactive features provided by the simulation increased student engagement and learning interest because cadets could independently explore system operations repeatedly without risking damage to actual equipment. This study highlighted the importance of visualization and interactivity in simplifying complex technical concepts in aviation training environments.

Similarly, Yunita et al. (2021) developed a browser-based virtual simulation platform designed for ventilator calibration training in the healthcare engineering field. Although conducted outside the aviation sector, the study demonstrated relevant findings regarding the effectiveness of simulation-based technical

learning. The virtual platform allowed users to simulate calibration procedures, analyze parameter adjustments, and identify operational errors within a safe and controlled digital environment. One of the major advantages identified in the study was the flexibility of access, as the browser-based system enabled students to conduct learning activities remotely without requiring physical laboratory attendance. The researchers found that the simulation platform improved technical understanding, reduced dependence on physical equipment, and increased training efficiency by minimizing setup time and equipment preparation procedures. Furthermore, students reported higher confidence levels in performing actual calibration tasks after practicing through the simulation system. The findings suggest that digital simulation technology can effectively bridge the gap between theoretical instruction and practical skill development in technical education.

In another related study, Sabrinah et al. (2021) developed a virtual laboratory application for measurement instrument training aimed at improving student learning outcomes in engineering education. The virtual laboratory was designed to replicate practical measurement activities that are commonly conducted using physical instruments in laboratories. Through the application, students could interact with virtual measuring devices, conduct simulated experiments, and receive immediate feedback regarding procedural accuracy and measurement results. The study reported that students who utilized the virtual laboratory application achieved better learning outcomes compared to those who relied solely on traditional teaching methods. In addition to improving academic performance, the application also enhanced student motivation and independent learning behavior because learners were able to practice repeatedly at their own pace. The virtual laboratory approach was also considered beneficial in overcoming limitations related to laboratory availability, equipment shortages, and maintenance costs.

Collectively, these previous studies demonstrate that simulation-based learning media have strong potential to improve technical education quality by creating more interactive, flexible, and student-centered learning environments. Simulation technology not only enhances conceptual understanding but also supports the development of procedural skills, analytical thinking, and operational confidence. These findings are highly relevant to aviation vocational education, particularly in learning activities involving complex navigation systems such as glide path equipment. Therefore, the development of interactive simulation media for glide path operation and maintenance training can be considered a strategic solution to overcome current limitations in laboratory-based learning while simultaneously improving cadets' practical competencies and learning effectiveness.

Although previous studies have widely discussed the implementation of simulation-based learning media in technical and vocational education, research specifically focusing on the design and development of glide path operational simulation media using Smart Apps Creator for aviation vocational learning remains relatively limited. Most existing studies primarily utilized platforms such as Adobe Flash, desktop-based software, or browser-based applications as the main development tools for interactive simulations. While these platforms have demonstrated positive impacts on student understanding and training effectiveness, they also present several limitations related to accessibility, compatibility, maintenance, and development complexity, particularly in modern educational environments that increasingly require flexible and mobile learning solutions.

Earlier simulation systems developed using Adobe Flash, for example, were once widely used because they allowed developers to create interactive animations and multimedia-based educational content. However, Adobe Flash technology is now considered outdated due to the discontinuation of official support and compatibility issues with modern operating systems and web browsers. As a result, learning applications built using Flash can no longer be easily accessed on many current devices, reducing their long-term usability and sustainability in educational institutions. In addition, Flash-based applications generally require specific technical skills in animation scripting and multimedia programming, which can become obstacles for educators or researchers who do not possess advanced programming backgrounds.

Similarly, browser-based simulation platforms provide advantages in terms of online accessibility and remote learning implementation. Students can access learning materials through internet-connected devices without installing additional software. However, browser-based systems also depend heavily on internet stability and network infrastructure. In many vocational learning environments, particularly in laboratory or workshop settings, unstable internet connectivity may disrupt learning activities and reduce the effectiveness of simulation usage. Furthermore, browser-based applications often require server maintenance, periodic updates, and additional technical support, which may increase operational complexity for educational institutions.

In this context, Smart Apps Creator (SAC) emerges as a promising alternative platform for the development of interactive multimedia learning applications, particularly for vocational and technical education. Smart Apps Creator is an application development platform that allows users to create interactive multimedia content without requiring advanced programming or coding skills. Through its user-friendly drag-and-drop interface, educators and researchers can design learning applications containing animations, videos, audio explanations, simulations, quizzes, and interactive navigation features more efficiently. This characteristic is highly beneficial for educational practitioners who may have limited software development expertise but still need to produce engaging digital learning media.

One of the major advantages of Smart Apps Creator is its ability to support offline operation across multiple platforms, including computers, tablets, and smartphones. Unlike browser-based systems that require continuous internet access, SAC applications can operate independently after installation, making them highly suitable for workshop and laboratory learning environments where internet access may be limited or inconsistent. This offline capability also enables cadets to access simulation materials anytime and anywhere, supporting independent learning and repeated practice outside formal laboratory schedules.

Additionally, Smart Apps Creator supports multimedia integration in a more flexible and visually appealing manner. Complex operational concepts related to glide path systems—such as signal transmission, glide slope visualization, antenna radiation patterns, aircraft approach alignment, and navigation parameter adjustments—can be presented through interactive animations and visual simulations that are easier for cadets to understand compared to static explanations in textbooks or presentation slides. The interactive nature of SAC-based applications also encourages active learning participation, where cadets can directly interact with menus, operational scenarios, and simulation controls instead of passively observing instructor demonstrations.

Another important advantage is the relatively simple and efficient development process. Compared to conventional software programming methods, Smart Apps Creator significantly reduces application development time because it does not require complex coding structures. This efficiency enables faster prototyping, easier content revision, and more adaptive learning media development according to institutional needs. Furthermore, SAC applications can be exported into various formats, including Android applications, desktop applications, and HTML-based outputs, increasing the flexibility of implementation across different learning devices and environments.

Despite these advantages, research investigating the application of Smart Apps Creator specifically for aviation navigation system simulations, particularly glide path operational learning, remains scarce. Most existing SAC-based educational applications are still concentrated in general education subjects, language learning, or basic science instruction. Therefore, the development of a glide path operational simulation using Smart Apps Creator represents both an innovative educational approach and a relevant contribution to aviation vocational learning development. This research can help expand the utilization of SAC technology in highly specialized technical training environments while also providing more interactive, accessible, and cost-effective learning solutions for aviation cadets.

Based on the conditions and limitations identified in current aviation vocational learning practices, this study focuses on the design and development of a glide path simulation application using Smart Apps Creator as an interactive learning medium for cadets at Makassar Aviation Polytechnic. The research is motivated by the need to provide a more adaptive, visual, and technology-supported learning approach that can enhance cadets' understanding of aviation navigation systems, particularly the operational principles of the Instrument Landing System (ILS) glide path component. Considering that glide path systems are highly technical and involve complex signal-processing concepts, conventional learning methods based solely on lectures, textbooks, and instructor demonstrations are considered insufficient to fully support practical comprehension and operational readiness among cadets.

The glide path system itself is a critical component of the Instrument Landing System that provides vertical guidance information to pilots during aircraft approach and landing procedures. Because the system directly affects flight safety and landing precision, aviation cadets are required to understand not only the theoretical principles but also the operational workflow, signal interpretation, equipment configuration, and troubleshooting procedures associated with glide path operations. However, due to the limited availability of laboratory equipment, restricted practice time, and operational risks associated with direct equipment handling, cadets often experience difficulties in obtaining sufficient practical exposure. Therefore, the development of an interactive simulation-based learning medium becomes an important solution to bridge the gap between theoretical instruction and practical operational understanding.

This study specifically proposes the development of a glide path simulation application utilizing Smart Apps Creator, a no-code multimedia development platform that enables the creation of interactive educational applications without requiring advanced programming skills. The use of Smart Apps Creator allows the researcher to integrate various multimedia components into a single learning platform, including interactive animations, operational videos, explanatory audio narration, graphical interfaces, navigation-based menus, and simulation scenarios that replicate the operational environment of glide path systems. Through these features, cadets can observe and interact with simulated navigation system processes in a more immersive and engaging manner compared to traditional instructional approaches.

One of the major novelties of this research lies in the integration of aviation navigation learning materials with interactive multimedia technology specifically designed for vocational aviation education. Previous studies generally focused on simulation media using Adobe Flash or browser-based systems with limited multimedia interactivity and dependency on internet connectivity. In contrast, this research introduces a Smart Apps Creator-based application that supports offline operation and multi-platform accessibility, allowing cadets to access learning materials through computers, laptops, or mobile devices without requiring continuous internet access. This characteristic significantly increases learning flexibility and supports independent practice beyond scheduled laboratory sessions.

Another important novelty is the incorporation of aviation-specific operational simulation interfaces into a no-code development environment. The application is not merely designed as a static digital learning module but as an interactive simulation platform that replicates glide path operational procedures and navigation system interactions visually. Cadets can explore menu-based operational sequences, observe simulated signal transmissions, understand glide slope concepts through animated visualization, and interact with procedural simulations step-by-step. The inclusion of multimedia elements such as instructional videos and audio explanations further enhances conceptual clarity by addressing different learning styles among cadets, including visual, auditory, and kinesthetic learning preferences.

In addition, the application is expected to support student-centered learning approaches by enabling cadets to learn independently and repeatedly according to their individual pace and level of understanding. Unlike instructor-centered demonstrations that often limit active participation, the simulation application encourages cadets to actively explore operational features, repeat simulation scenarios, and review materials whenever necessary. This repetitive and self-directed learning process is particularly important in aviation education, where procedural accuracy, technical familiarity, and operational discipline must be developed continuously through repeated practice and exposure.

From an institutional perspective, the development of this simulation application can also provide practical advantages for Makassar Aviation Polytechnic. The application may help reduce dependency on direct use of sensitive laboratory equipment during introductory learning stages, thereby minimizing the risk of equipment misuse and reducing maintenance burdens. Furthermore, the use of digital simulation media can improve laboratory learning efficiency by allowing cadets to build foundational operational understanding before conducting direct practical sessions with actual glide path equipment.

Therefore, this research is expected to contribute significantly to the improvement of aviation vocational education quality, particularly in the field of aviation navigation systems and Instrument Landing System operations. The integration of interactive multimedia technology, simulation-based learning, and no-code application development represents an innovative educational approach that aligns with current digital learning trends and industry competency demands. Ultimately, the developed application is expected to enhance cadets' conceptual understanding, operational competence, learning motivation, and readiness to perform aviation navigation procedures in real operational environments.

## **METHOD**

This study employed the Design and Development (D&D) research approach, which emphasizes the systematic process of designing, developing, and evaluating educational products to address practical learning problems while contributing to instructional innovation. Unlike experimental research, D&D research focuses on producing functional educational products through iterative design and development processes that are grounded in identified user needs and contextual learning environments. The D&D approach was selected because the primary objective of this research was not to compare learning outcomes statistically, but to develop an interactive Glide Path Simulation application that could support aviation vocational learning. The resulting product was expected to facilitate cadets' understanding of Instrument Landing System (ILS) operations by providing an accessible and interactive multimedia learning environment. The research was

conducted at the Air Navigation Technology Laboratory of Makassar Aviation Polytechnic. The developed product was an interactive multimedia application created using Smart Apps Creator (SAC), a no-code multimedia development platform capable of integrating text, graphics, animations, videos, audio narration, and interactive navigation into a single learning application.

The development process consisted of four systematic stages: needs analysis, application design, application development, and functional testing. Each stage was carried out sequentially to ensure that the final product fulfilled the intended learning objectives and technical requirements.

### 1. Need Analysis

The first stage focused on identifying instructional needs related to Glide Path learning. Data were obtained through direct observation of learning activities in the Air Navigation Technology Laboratory, analysis of laboratory facilities, review of operational manuals, curriculum documents, and supporting literature concerning Instrument Landing System (ILS) operations. This analysis identified several instructional challenges. Practical learning opportunities were limited because Glide Path equipment is categorized as sensitive aviation navigation equipment that requires controlled operational procedures. Laboratory sessions were also constrained by equipment availability and scheduled practice time. Consequently, cadets had limited opportunities to repeatedly observe operational procedures and system behaviour. These conditions indicated the need for an alternative learning medium capable of visualizing operational processes while supporting independent learning outside scheduled laboratory activities.

### 2. Application Design

Based on the identified learning needs, the application structure was designed to support sequential learning of Glide Path operations. The instructional content was organized into several interconnected modules to facilitate gradual understanding of theoretical concepts and operational procedures. The application architecture consisted of the following learning components:

- ✓ Main Menu
- ✓ Instrument Landing System Theory
- ✓ Glide Path System Overview
- ✓ Glide Path Components
- ✓ Operational Procedures
- ✓ Parameter Explanation
- ✓ Interactive Simulation
- ✓ Navigation and Exit Functions

During this stage, interface layouts, navigation structures, multimedia placement, user interaction flows, and learning sequences were designed to ensure consistency, usability, and ease of operation.

### 3. Application Development

The application was developed using Smart Apps Creator, a multimedia authoring platform that enables application development without conventional programming. Learning materials were compiled from laboratory manuals, operational documentation, aviation references, and instructional materials used in the Air Navigation Technology Study Program. Several multimedia components were then integrated into the application, including:

- ✓ instructional text;
- ✓ equipment photographs;
- ✓ technical diagrams;
- ✓ operational animations;
- ✓ instructional videos;
- ✓ audio narration;
- ✓ interactive navigation buttons;
- ✓ simulation pages.

Interactive navigation was implemented to allow users to move freely between learning modules while maintaining structured learning sequences. The completed application was exported into executable desktop and mobile formats, enabling offline operation without requiring continuous internet connectivity.

#### 4. Functional Text

The final stage consisted of functional testing to verify whether every feature operated according to the predetermined design specifications. Testing was conducted using the Black-box Testing approach because the primary objective was to evaluate application functionality from the user's perspective without examining the internal source code. Each functional component was evaluated individually, including:

- ✓ main menu navigation;
- ✓ page transitions;
- ✓ button functionality;
- ✓ multimedia playback;
- ✓ animation performance;
- ✓ simulation interaction;
- ✓ audio playback;
- ✓ desktop application execution.

Each feature was tested repeatedly under normal operating conditions to verify functional consistency, responsiveness, and operational stability. A feature was categorized as successful when its actual output matched the expected system behaviour defined during the design stage.

##### a. Data Collection

Data collection was conducted using three complementary techniques to support the development process.

1. Observation was carried out to identify learning conditions, laboratory facilities, and practical activities related to Glide Path operations.
2. Documentation included the collection of laboratory manuals, operational procedures, equipment documentation, curriculum materials, and multimedia resources used during application development.
3. Literature Review was conducted to obtain theoretical foundations related to Instrument Landing System technology, multimedia learning, simulation-based learning, instructional media development, and Smart Apps Creator implementation.

##### b. Data Analysis Techniques

The collected data were analysed using descriptive qualitative analysis to evaluate both the product development process and application functionality. The analysis emphasized the consistency between the planned application design and the implemented product. Functional testing results obtained from Black-box Testing were compared with predefined operational specifications to determine whether each feature operated correctly. The evaluation focused on several aspects, including:

- ✓ functional accuracy;
- ✓ navigation consistency;
- ✓ multimedia integration;
- ✓ user interaction;
- ✓ application stability;
- ✓ compatibility across supported devices.

Testing results were summarized descriptively using tables and narrative explanations to provide a comprehensive overview of the application's operational performance. The findings were subsequently interpreted to determine whether the developed application fulfilled the intended instructional objectives and technical requirements as an interactive learning medium for Glide Path operation.

The collected data were analyzed descriptively to evaluate both the technical performance and educational effectiveness of the developed simulation application. The analysis focused on interpreting the results of functional testing conducted on each feature and system component. Functional testing was performed to verify whether all modules, interfaces, controls, and simulation processes operated according to the predefined system requirements and design specifications. The testing process included evaluating user input handling, system responses, navigation functionality, simulation accuracy, error handling, and overall application stability. Each function was tested under various scenarios to ensure consistency, reliability, and usability. The obtained results were then categorized into successful operations, minor issues, and failed operations to identify areas requiring improvement.

In addition, the descriptive analysis examined how effectively the application supported the intended learning objectives. This involved assessing whether the simulation provided clear visualizations, interactive learning experiences, and understandable outputs that could enhance users' comprehension of the targeted concepts. User feedback and observation data, when available, were also interpreted to determine the application's practicality, ease of use, and engagement level. The findings from the analysis were presented in the form of tables, percentages, and narrative explanations to provide a comprehensive overview of the application's operational performance and educational suitability. Based on these interpretations, conclusions were drawn regarding the extent to which the developed simulation application fulfilled the expected operational standards and learning outcomes.

## **RESULTS AND DISCUSSION**

### **A. Result**

#### **1. Overview of the Developed Application**

The primary outcome of this study is an interactive Glide Path Simulation application developed using Smart Apps Creator (SAC). The application was designed as a multimedia-based learning medium to facilitate cadets' understanding of the operational principles of the Instrument Landing System (ILS), particularly the Glide Path subsystem. Unlike conventional instructional media that primarily rely on textual explanations and instructor demonstrations, the developed application integrates various multimedia components into a unified learning environment.

The application combines instructional text, photographs, technical illustrations, animations, audio narration, instructional videos, and interactive navigation features. These multimedia elements were intentionally integrated to improve conceptual visualization and support independent learning. The application can be executed on desktop computers and Android devices without requiring continuous internet connectivity, enabling cadets to access learning materials both inside and outside laboratory sessions.

The overall application architecture was designed to provide sequential learning experiences beginning with fundamental theoretical concepts and progressing toward operational simulation activities. This structure enables learners to acquire conceptual understanding before exploring operational procedures through interactive multimedia.

#### **2. Application Structure**

The developed application consists of several interconnected learning modules that guide users through the learning process systematically.

- ✓ The Main Menu serves as the primary navigation interface connecting all learning components. From this page, users can access theoretical materials, operational explanations, parameter descriptions, simulation activities, and supporting multimedia resources.
- ✓ The Instrument Landing System (ILS) Theory module introduces the fundamental concepts of precision approach systems, explaining the functions of the Localizer, Glide Path, and Marker Beacon within aircraft landing operations.
- ✓ The Glide Path Module explains the operational principles of the Glide Path equipment, including signal transmission mechanisms, vertical guidance concepts, antenna systems, and aircraft approach alignment.
- ✓ The Operational Procedure Module presents the standard operating procedures for activating and operating Glide Path equipment. Learning materials are supported by instructional videos and sequential animations that illustrate each operational step.
- ✓ The Parameter Module explains important operational parameters used in Glide Path systems, allowing cadets to understand the relationship between equipment settings and aircraft guidance.
- ✓ Finally, the Simulation Module provides an interactive learning environment in which users can navigate through operational sequences while observing multimedia explanations that represent actual operational conditions.

#### **3. Multimedia Integration**

One of the main characteristics of the developed application is the integration of various multimedia components into a single instructional platform. The application incorporates several instructional media, including:

- ✓ textual explanations;
- ✓ equipment photographs;
- ✓ technical diagrams;
- ✓ operational animations;
- ✓ instructional videos;
- ✓ audio narration;
- ✓ interactive navigation buttons;
- ✓ simulation interfaces.

Each multimedia component was selected according to its instructional function. Text provides conceptual explanations, images facilitate equipment recognition, animations illustrate invisible operational processes, videos demonstrate operational procedures, and audio narration reinforces important information during learning activities. This multimedia integration creates a more engaging learning experience while helping cadets understand complex navigation concepts more effectively.

#### 4. Functional Testing Results

The developed application was evaluated through functional testing using the Black-box Testing approach. The objective of this evaluation was to determine whether every functional component operated according to the predetermined system specifications. Eight major application features were evaluated, including navigation, multimedia playback, interactive functions, animation performance, and desktop execution.

Table 1. Functional Testing Results of the Glide Path Simulation Application

No	Feature Tested	Expected Result	Testing Result
1	Main Menu	Navigate to all modules correctly	Successful
2	Theory Module	Display instructional materials properly	Successful
3	Video Playback	Play instructional videos smoothly	Successful
4	Navigation Buttons	Move between pages correctly	Successful
5	Animation Module	Display animation without errors	Successful
6	Simulation Module	Execute interactive simulations properly	Successful
7	Audio Playback	Play narration correctly	Successful
8	Desktop Export	Run application successfully	Successful

The testing results demonstrate that every functional component performed according to the design specifications. No functional errors were identified during testing, indicating that the developed application fulfilled the intended operational requirements as an interactive multimedia learning application.

#### 5. Product Characteristics

Based on the development process and functional evaluation, several characteristics distinguish the developed application from conventional instructional media.

- 1) The application supports offline learning, enabling cadets to access instructional materials without internet connectivity. This feature is particularly beneficial in laboratory environments where network availability may be limited.
- 2) The multimedia integration enables abstract aviation navigation concepts to be visualized more clearly than conventional printed learning materials.
- 3) The application provides interactive navigation that allows learners to determine their own learning sequence while maintaining structured instructional guidance.
- 4) The application can be distributed across multiple desktop and Android devices without requiring additional software installation or programming configuration.

Collectively, these characteristics demonstrate that the developed application is technically feasible for implementation as an interactive learning medium in aviation vocational education.

#### B. Discussion

The development of the Glide Path Simulation application demonstrates that interactive multimedia technology can be effectively utilized to support vocational aviation education, particularly in learning activities involving complex navigation systems. The integration of multimedia elements, including text, images, animations, instructional videos, audio narration, and interactive navigation, creates a learning environment that enables cadets to understand theoretical concepts and operational procedures in a more systematic and engaging manner. One of the primary strengths of the developed application lies in its ability to visualize operational processes that are difficult to observe directly during conventional classroom instruction. Glide Path operation involves radio signal transmission, antenna radiation patterns, aircraft approach alignment, and vertical guidance principles that cannot be easily demonstrated using traditional teaching methods. Through interactive animations and multimedia visualization, these abstract concepts become more concrete and understandable. This finding supports the Cognitive Theory of Multimedia Learning proposed by Mayer (2014), which explains that learning becomes more effective when information is presented through complementary verbal and visual channels. The simultaneous presentation of narration, graphics, animation, and textual explanations facilitates the construction of meaningful mental representations while reducing unnecessary cognitive processing.

The interactive characteristics of the application also reflect the principles of learner-centered instruction. Rather than relying solely on instructor demonstrations, cadets are able to explore learning materials independently according to their individual learning pace. They can repeatedly review theoretical explanations, replay instructional videos, and navigate simulation modules whenever necessary. Such flexibility encourages self-directed learning, which is considered an essential component of competency-based vocational education where procedural understanding and repeated practice play a central role in developing professional skills. Another important contribution of the developed application is its support for independent learning beyond laboratory sessions. Aviation laboratories generally operate under strict scheduling and safety procedures because navigation equipment is sensitive and requires careful handling. Consequently, opportunities for repeated practice using actual Glide Path equipment are naturally limited. By providing an offline multimedia simulation that can operate on desktop and mobile devices, the application extends learning opportunities beyond the physical laboratory. Cadets are therefore able to review operational concepts and procedural sequences without depending on laboratory availability or internet connectivity. From a technological perspective, the use of Smart Apps Creator provides practical advantages for educational media development. Unlike conventional software development that requires programming expertise, Smart Apps Creator enables multimedia applications to be developed using a no-code environment. This considerably simplifies the development process while allowing instructional designers and educators to integrate diverse multimedia resources into a single application. Such characteristics are particularly relevant for vocational education institutions where educational innovation is often constrained by limited programming expertise and development resources.

The findings of this study are consistent with previous research emphasizing the effectiveness of simulation-based learning in technical education. Ariyanti (2019) reported that simulation media for Instrument Landing System calibration improved cadets' conceptual understanding by enabling visualization of operational processes that are otherwise difficult to observe directly. Similarly, Yunita et al. (2021) demonstrated that browser-based virtual simulations increased technical understanding by allowing learners to repeatedly practice procedural activities within a controlled digital environment. Likewise, Sabrinah et al. (2021) concluded that virtual laboratory applications improved learning outcomes by providing interactive and flexible practical experiences. The present study extends these findings by applying multimedia simulation specifically to Glide Path operational learning within aviation vocational education and by utilizing Smart Apps Creator as a no-code multimedia development platform capable of supporting offline learning across multiple devices. Although this research successfully developed a functional multimedia application, several limitations should be acknowledged. The scope of the developed simulation is limited to the Glide Path subsystem of the Instrument Landing System and does not yet include other navigation components such as the Localizer or Marker Beacon. In addition, the evaluation focused primarily on functional performance through Black-box Testing and did not measure instructional effectiveness using experimental learning outcomes. Consequently, the present study should be viewed as an initial development study that establishes the technical feasibility of the application rather than providing evidence of comparative learning effectiveness.

Future research should therefore extend the current work by incorporating instructional effectiveness evaluations involving cadets through classroom implementation, usability assessments, and comparative learning studies. The simulation platform may also be expanded to integrate additional Instrument Landing System components and other aviation navigation systems, thereby providing a more comprehensive digital learning ecosystem for aviation vocational education.

## **CONCLUSION**

This study successfully designed and developed an interactive Glide Path Simulation application using Smart Apps Creator as a multimedia learning medium for aviation vocational education at Makassar Aviation Polytechnic. The development process followed a systematic Design and Development (D&D) approach, beginning with instructional needs analysis, application design, multimedia development, and functional testing. The resulting application integrates instructional text, technical illustrations, animations, instructional videos, audio narration, and interactive navigation into a single multimedia platform that supports both desktop and Android devices in offline mode.

The results of functional evaluation using Black-box Testing indicate that all application features operated according to the predetermined design specifications. Navigation systems, multimedia playback, animation, interactive simulation, and application execution functioned successfully without significant operational errors. These findings demonstrate that the developed application is technically feasible as an interactive learning medium for supporting the delivery of Glide Path operational materials.

This study contributes to aviation vocational education by providing an alternative digital learning medium that enhances visualization of complex navigation concepts and supports independent learning beyond laboratory sessions. The application also demonstrates the potential of Smart Apps Creator as a practical no-code platform for developing multimedia instructional applications in technical education.

Nevertheless, this research focused primarily on the design, development, and functional verification of the application. Therefore, future studies are recommended to investigate the instructional effectiveness of the developed application through classroom implementation, usability evaluation, and learning outcome assessment involving aviation cadets. Further development may also expand the simulation to include other Instrument Landing System components and additional aviation navigation systems to provide a more comprehensive digital learning environment.

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