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DESIGNING A USER- CENTERED MOBILE APPLICATION TO ENHANCE PROGRAMMING SKILLS AMONG HIGH SCHOOL LEARNERS.

BY

Kokerai Chikerema (B1334872)

SUPERVISOR: Dr T. CHIKEREMA

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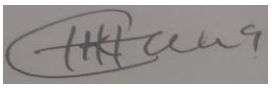

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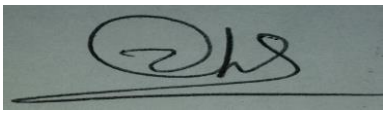

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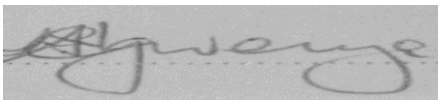

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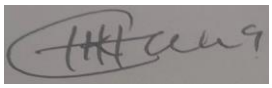

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1 Chapter 1: Introduction to the Study

Programming skills are increasingly essential in today's digital world, serving as a foundational literacy for numerous careers and daily problem-solving. However, many high school students find learning programming challenging due to a confluence of factors, including traditional teaching methods, a lack of engaging learning tools, and limited access to practical, interactive resources. This project aims to bridge this critical gap by designing a mobile application specifically tailored to enhance programming learning experiences for high school students through interactive and personalized features. Through the Internet, information technology is a way for the world to generate the multiplier effect of learning (Wu & Tai, 2016).

1.1 Background and Context

The demand for programming proficiency has surged across industries, making it a critical skill for the 21st century workforce (World Economic Forum, 2016). Despite this growing imperative, the current landscape of programming education for high school students often presents significant hurdles. Traditional classroom settings, while valuable, can sometimes struggle to keep pace with the dynamic nature of technology, relying on methods that may not fully engage digitally native learners (Prensky, 2001). This often results in a passive learning experience that prioritizes theoretical understanding over practical application.

Furthermore, students frequently face a dearth of engaging tools that make programming concepts accessible and enjoyable. Textbooks and static online tutorials, while informative, can lack the interactivity needed to truly grasp complex logical structures and problem-solving techniques inherent in coding (Shute & Sun, 2015). This can lead to disengagement and a perception of programming as an abstract and difficult subject. Compounding these issues is limited access to practical resources, such as dedicated coding environments or real-time feedback mechanisms, which are crucial for developing genuine programming fluency. Many students, especially those in underserved communities, may lack consistent access to computers or reliable internet, further widening the educational divide (Warschauer, 2004).

1.2 The Intervention of Mobile Apps

Mobile applications present a powerful solution to these challenges, offering ubiquitous accessibility and interactive learning opportunities. With the widespread adoption of

smartphones among high school students, mobile apps can transform learning from a rigid, classroom-bound activity into a flexible and engaging experience available anytime, anywhere (Sharples et al., 2007). These platforms can leverage multimedia elements, gamification, and instant feedback to make abstract programming concepts more concrete and enjoyable (Dicheva et al., 2015). The portability and personal nature of mobile devices also mean that learning can be integrated seamlessly into a student's daily routine, fostering a habit of continuous engagement with programming concepts.

1.3 Challenges Faced by Current Mobile Apps

Despite the clear potential, existing mobile applications for learning programming often fall short in adequately addressing the unique needs of high school students. A primary limitation is the lack of user-centered design, meaning many apps are not specifically tailored to the cognitive development, attention spans, or learning preferences of this demographic (Hwang & Chang, 2016). They may be overly complex, feature-rich to the point of being overwhelming, or conversely, too simplistic to offer substantial learning.

Another common challenge is the insufficient incorporation of engaging pedagogical techniques. While some apps include quizzes or basic coding challenges, they often lack sophisticated gamification elements that truly motivate sustained learning, or they fail to offer personalized learning paths that adapt to individual student progress and areas of difficulty (López-Peñalver et al., 2018). Many current apps also struggle with providing meaningful and immediate feedback, which is crucial for learners to understand their mistakes and correct their understanding of programming logic (van der Kleij et al., 2015). Furthermore, the depth of content can be an issue, with some apps offering only superficial introductions to programming languages rather than guiding students through more complex problem-solving scenarios.

1.4 Purpose and Significance of This Project

The purpose of this project is to design, prototype, and evaluate a user-centered mobile application specifically crafted to enhance programming skills among high school students. This application will directly address the identified limitations of current educational tools by prioritizing engaging, interactive, and personalized learning experiences. Through a rigorous design process informed by the needs and preferences of the target audience, we aim to create

a solution that not only teaches programming concepts but also fosters critical thinking, problem-solving abilities, and a genuine passion for computer science (Koedinger & Corbett, 2006).

The significance of this project extends beyond simply creating another learning tool. It represents a crucial step towards democratizing access to quality programming education, particularly for students who may not have traditional avenues. By providing an accessible and motivating platform, this project seeks to empower high school students with essential 21st-century skills, opening doors to future academic and career opportunities in technology. It also aims to contribute valuable insights into effective educational technology design, specifically for mobile learning environments, which can inform future developments in this rapidly evolving field (Traxler, 2009).

1.5 Problem Statement

Clear articulation of the current limitations in mobile apps in learning programming skills
Impact of these limitations on resource access and usability

1.6 Objectives

To analyze the specific needs and preferences of high school students learning programming.
To design a user-friendly, engaging mobile application that incorporates gamification and personalized learning paths.
To prototype and implement the application, emphasizing usability and educational effectiveness.
To evaluate the application's usability and its impact on students' motivation and understanding of programming concepts.

1.7 Research Questions

1. What are the key challenges faced by high school students in learning programming?
2. How can a mobile application be designed to effectively address these challenges?
3. What are the usability and pedagogical benefits of the designed application?

1.8 Expected Outcomes

A functional prototype of a mobile learning app for programming.

Insights into effective design principles for educational mobile applications targeting high school learners.

Recommendations for integrating such tools into educational curricula.

1.9 Significance

This project holds significant implications for the field of computer science education. By providing an innovative, accessible tool, it directly addresses a critical need to motivate and support high school students in learning programming, a skill that is increasingly fundamental in a technology driven World. The mobile application developed will serve as a powerful supplement to traditional teaching methods, offering a flexible and engaging pathway for students to acquire fundamental coding knowledge and computational thinking skills (Grover, &Pea, 2013). It also has the potential to democratize access to quality programming education, particularly for students in resource-constrained environments who may lack access to specialised hardware or dedicated instructors (Wareschauer, 2004).

Furthermore, this endeavour offers practical experience in designing educational technology solutions. The process of analysing user needs, designing a user interface, developing a functional prototype, and rigorously evaluating its effectiveness provides invaluable hands-on experience in the entire software development lifecycle, specifically within the context of educational innovation (Shavelson et al., 2003). The insights gained from this project will not only contribute to academic literature on mobile learning and educational technology but also provide a tangible model for future development efforts aimed at making complex subjects more approachable and engaging for young learners (Traxler, 2009). Ultimately, this project aims to foster a new generation of computationally literate individuals, ready to tackle the challenges and opportunities of the digital age (World Economic Forum, 2016).

1.10 Scope

This project focuses on the design, prototyping, and initial evaluation of a user-centered mobile application aimed at enhancing programming skills among high school students. The scope encompasses:

i. Target Audience: High school students (ages approximately 14-18) with little to no prior programming experience.

ii. Core Functionality: The application will incorporate interactive lessons, gamification elements (e.g., points, badges, leaderboards) (Dicheva et al., 2015), personalized learning paths, and immediate feedback mechanisms for coding exercises (van der Kleij et al., 2015).

iii. Programming Concepts: The initial focus will be on foundational programming concepts, such as variables, data types, control structures (loops, conditionals), and basic functions, likely utilizing a beginner-friendly language (e.g., Visual Basic or block-based programming) (Kafura & Qin, 2013).

iv. Design Methodology: A user-centered design (UCD) approach will be employed, involving user research, iterative design, prototyping, and usability testing (Norman & Draper, 1986).

v. Evaluation: The evaluation will primarily focus on the application's usability, user engagement, and perceived impact on motivation and understanding of programming concepts among a small group of high school students (Ainsworth et al., 2011).

1.11Limitations

While striving for a comprehensive and impactful solution, this project is subject to certain limitations:

I. Limited Implementation: Due to time and resource constraints, the project will result in a functional prototype rather than a fully developed, production-ready application. This means a complete suite of advanced features, extensive content libraries, or robust backend infrastructure may not be fully realized.

II. Scope of Content: The application will cover foundational programming concepts. It will not delve into advanced topics, complex data structures, algorithms, or specific frameworks, which would require a much broader development effort (Ackerman, 2014).

III. Evaluation Size and Duration: The evaluation will involve a relatively small sample size of high school students and will be conducted over a limited period. This might restrict the generalizability of the findings regarding the long-term impact on programming skill acquisition (Creswell & Plano Clark, 2017).

IV. Technical Constraints: The choice of development platform and available resources may impose certain technical limitations on the application's features, performance, or compatibility across all mobile devices (Sharp et al., 2007).

V. External Factors: The project acknowledges that external factors such as students' access to reliable internet, availability of mobile devices, and existing school curricula can influence the effectiveness and adoption of the mobile application, which are beyond the direct control of this project (Hargittai, 2010)

VI. Real-world Deployment: This project does not include a full-scale deployment or integration into actual high school curricula, which would involve partnerships with educational institutions and a more extensive testing phase (Squire, 2008).

1.12 Structure of the Report

The final report will be structured into eight chapters: Introduction, Review of Related Literature, Requirements Analysis, Design Phase, Implementation, Evaluation, Discussion, and Conclusion & Recommendations. This structure will systematically present the research, design, and evaluation of the user-centered mobile application.

2 CHAPTER 2: Review of the Related Literature

2.1 Introduction

This literature review explores educational technology in programming education at the high school level, focusing on its application and effectiveness. It examines existing digital tools, apps, and platforms, and delves into the impact of gamification, interactive tutorials, and simulation-based learning on student engagement and learning outcomes.

Existing Digital Tools, Apps, and Platforms for Teaching Programming at the High School Level

The proliferation of digital tools, apps, and platforms has significantly transformed how programming is taught and learned in high schools. These resources offer diverse approaches, catering to various learning styles and experience levels.

2.2 Block-Based Programming Environments

Scratch (MIT Media Lab) is widely recognized as an entry point for young learners, using a visual, drag-and-drop interface that simplifies complex programming concepts like conditionals, loops, and variables. Its intuitive nature makes it ideal for introducing computational thinking and problem-solving skills without the hurdle of complex syntax (Resnick et al., 2009). Tynker offers a similar block-based approach, often integrating with educational games and activities to make learning engaging. MIT App Inventor is a visual programming environment that enables students to build fully functional Android and iOS mobile applications, bridging creativity with coding (Sharp et al., 2009).

2.3 Text-Based Programming Environments and Platforms

Codecademy is a popular online platform offering free and paid resources for beginner and intermediate learners, emphasizing interactive coding exercises and providing instant feedback across languages like Python, JavaScript, HTML, CSS, and SQL. CodeHS is specifically designed for high school programming classes, offering a structured curriculum in languages like Java, Python, and JavaScript. Visual Studio Code (VS Code), a free, versatile code editor from Microsoft, supports numerous programming languages, with debugging capabilities, source code management, and extensive extensions, making it a powerful tool for high schoolers transitioning to text-based coding.

2.4 Digital Classroom Management and Collaborative Tools

Google Classroom acts as a digital classroom assistant, facilitating assignment distribution, material sharing, and overall organization for teachers and students. Quizlet, while not strictly for coding, offers digital flashcards and study modes (matching games, mock tests) valuable for memorizing syntax, commands, and concepts in programming. Notion is a versatile workspace for note-taking, task management, and organizing study materials, useful for students to manage their programming projects and learning journey.

Effectiveness of Gamification, Interactive Tutorials, and Simulation-Based Learning

2.5 Effectiveness of Gamification

Increased Motivation and Engagement: Studies consistently show that gamified learning activities stimulate student interest, capture their attention, and encourage perseverance, particularly in subjects like programming that can be perceived as challenging. Elements such as points, badges, leaderboards, and challenges tap into intrinsic motivators and have been shown to significantly enhance enthusiasm and persistence in learners (Dicheva et al., 2015; Hamari et al., 2014).

Improved Academic Achievement (to a lesser extent): While motivation is a primary benefit, gamification has also been linked to improved academic achievement and critical thinking skills. For example, a longitudinal study found that gamified learning improved excellence rates by up to 122% compared to online learning and 70% compared to traditional learning (Barata et al.,2017). Strategy and puzzle games within gamified contexts have been particularly effective in enhancing cognitive engagement and academic performance (Wang et al., 2019.

Enhanced Self-Accomplishment and Self-Improvement: The progression and reward systems inherent in gamification foster a sense of accomplishment and encourage students to reflect on their learning and strive for continuous improvement. Research integrating gamification with self-regulated learning strategies has shown significant gains in self-efficacy, engagement, and reflective thinking (Stockler & Gouveia, 2018).

2.6 Effectiveness of Interactive Tutorials

Immediate Feedback: A major advantage is the instant feedback loop. As students write code, they receive immediate responses on syntax errors, logical flaws, and successful implementations. This rapid feedback is crucial for correcting misconceptions and reinforcing

correct practices. Research shows that immediate feedback significantly improves learning outcomes by helping students adjust their understanding in real time (Nakagawa et al., 2016).

Hands-on Application: Interactive tutorials enable learners to immediately apply what they are learning, which leads to better retention of coding concepts and practices. This "learning by doing" approach aligns with constructivist learning theory and has been shown to improve both engagement and academic performance (Hmelo-Silver, 2004).

Self-Paced and Adaptive Learning: Many interactive platforms allow students to learn at their own pace, revisiting concepts as needed. Some incorporate adaptive learning algorithms that tailor content and difficulty based on individual progress and performance, providing personalized learning paths. Studies highlight that such self-paced environments support diverse learners and improve conceptual understanding when students are motivated and guided effectively (Corbett & Koedinger, 1997).

Problem-Solving Focus: Interactive tutorials often present coding challenges and algorithmic puzzles, directly fostering practical problem-solving skills that are essential in programming. These activities promote critical thinking and have been linked to improved learner engagement and deeper understanding of complex concepts (Savery, 2006).

Simulation-Based Learning

Experiential Learning and Risk-Free Practice: Simulations allow learners to experiment, make errors, and experience the consequences in a safe, controlled environment. This fosters confidence and encourages repeated practice without real-world risks. Studies in nursing and medical education confirm that simulation-based learning (SBL) enhances clinical judgment and skill acquisition through experiential learning (Jeffries, 2005) .

Enhanced Comprehension and Retention: By bridging the gap between theory and practice, simulations significantly improve conceptual understanding and long-term retention. Research shows that students retain knowledge more effectively through simulation than traditional lecture-based methods (Cook et al., 2011).

Development of Critical Thinking and Problem-Solving Skills: Simulations immerse students in problem-based scenarios that require analysis, decision-making, and application of knowledge. This approach has been shown to improve critical thinking and creative problem-

solving skills, especially when combined with collaborative learning strategies (Gullo & Arthur-Kelly, 2011

2.7 Mobile Learning and Educational Technologies

Mobile learning (m-learning) has become a core part of modern education, offering flexible, accessible, and personalized learning. Thanks to smartphones, tablets, and improved connectivity, it's widely used across all levels of education (Traxler, 2009). M-learning's biggest advantage is flexibility it enables learners to study anytime, anywhere, which suits digital natives and busy lifestyles (Sharples et al., 2007). It also expands access, helping overcome geographic and resource limitations. Learners can personalize their experience by choosing content, setting their pace, and following tailored learning paths. Interactive elements like videos, quizzes, and gamification boost engagement, while real-time feedback from mobile apps strengthens communication and supports progress tracking (Kukulska-Hulme & Pettit, 2015).

The m-learning ecosystem includes smartphones, tablets, and LMS mobile apps like Moodle and Canvas, which provide access to materials, discussions, and alerts. Dedicated apps such as Duolingo, Quizlet, and Khan Academy support learning in specific subjects. Cloud computing ensures content is synchronized across devices, and artificial intelligence personalizes the learning journey with adaptive feedback and recommendations (Liu et al., 2019).

2.8 Principles of Mobile App Design for Educational Purposes

Effective educational app design starts with a **user-centric approach** understanding learner needs, preferences, and tech abilities through research and testing (Norman & Draper, 1986). Apps should prioritize **simplicity and clarity**, using clean, intuitive interfaces with minimal distractions and clearly labelled elements (Nielsen, 1993). **A consistent design** across visuals and interactions helps users develop familiarity and reduces cognitive load (Lidwell et al., 2003).

Intuitive navigation is essential, supported by logical layouts and familiar patterns like bottom bars or hamburger menus, with an emphasis on vertical scrolling (Nieslsen, 1993) **Immediate feedback** visual, tactile, or auditory enhances user control and confidence (Shute & Sun, 2015). Strong **usability** ensures the app is easy to learn, efficient to use, forgiving of mistakes, and enjoyable overall.

Designing with a **mobile-first mind set** means optimizing for touch, small screens, and single-hand use rather than adapting desktop layouts (Harples etal., 2007). Good **readability and**

visual hierarchy guide attention using legible fonts, clear contrast, and well-organized content. Since attention spans are shorter on mobile, **micro learning** short, focused content is key (Hodgins, 2014).

App performance also matters: fast load times, smooth animations, and optimized code enhance the user experience (Westermann et al., 2018). Finally, robust **data security and privacy** protections build trust and safeguard user information (FIPS 140-2, 2013)

Best Practices for User Engagement, Usability, and Accessibility in Mobile Learning Tools

One of the most impactful techniques for boosting engagement is gamification, which integrates elements like points, badges, leaderboards, and challenges to motivate learners and make the experience more enjoyable. These game-like features, especially when paired with narrative elements, foster a sense of competition and achievement that enhances motivation (Geek Mode Editorial, 2024).

Equally important is the use of interactive content, quizzes, drag-and-drop tasks, simulations, videos, infographics, and scenario-based activities that encourages active learning and accommodates various learning styles (Inkling, 2024). Personalization further enhances engagement by tailoring the learning journey to individual users through adaptive paths, progress tracking, and custom dashboards, making the experience feel more relevant and motivating (Sopianti & Prasetyo, 2025; Training Industry, 2021).

Designing content around real-world scenarios helps learners connect abstract concepts to practical applications, increasing intrinsic motivation (eLearning Industry, 2024). This is reinforced by frequent and meaningful feedback, which celebrates progress and guides learners through mistakes, creating a positive reinforcement loop that supports retention.Incorporating storytelling into learning modules can deepen emotional engagement and improve memory retention by embedding content within relatable narratives (Research.com, 2025). Additionally, collaborative features such as discussion forums and shared activities promote peer interaction and social learning, which are vital for engagement and knowledge construction (EducateMe, 2025).

Push notifications, when used judiciously, can gently remind users of upcoming tasks or new content without overwhelming them. Finally, a visually appealing interface featuring high-quality graphics, intuitive layouts, and multimedia—enhances immersion and makes the learning experience more enjoyable and accessible (Digital Learning Edge, 2024).

2.9 Usability Best Practices

Designing for usability in mobile learning begins with a mobile-first approach, ensuring that the app is optimized from the ground up for smaller screens, touch interactions, and on-the-go usage (Inkling, 2024). A seamless and intuitive user journey is essential navigation should be clear, logical, and require minimal effort to move between sections or locate content. This is supported by a minimalist design philosophy, where only essential information is displayed on each screen to reduce cognitive load and avoid visual clutter.

To ensure consistency across devices, responsive design is key. The app should adapt fluidly to various screen sizes and resolutions, maintaining a uniform experience whether accessed on a smartphone or tablet (eLearning Industry, 2024). Content must also be optimized for mobile consumption, broken into short, digestible chunks using a mix of text, visuals, and video. Media should be compressed and optimized for low-bandwidth environments to ensure accessibility in areas with limited connectivity.

Language clarity plays a crucial role in usability clear and concise wording helps users quickly understand instructions and content without confusion. Interactive elements like buttons and links should feature accessible touch targets, with adequate size and spacing to support easy tapping and reduce accidental inputs. Given the variability in internet access, offering offline capabilities allows learners to download and engage with content without needing a constant connection (eLearning Industry, 2024). To ensure the app meets real-world needs, thorough user testing should be conducted regularly with representative users. This helps identify usability issues early and refine the experience based on actual feedback.Finally, performance optimization is non-negotiable. Fast load times and smooth transitions are critical to maintaining user satisfaction and preventing frustration. Together, these practices create a mobile learning environment that is intuitive, efficient, and enjoyable to use.

2.10 Best Practices for Accessibility in Mobile Learning Tools

Accessibility in mobile learning ensures that educational content is usable by everyone, including individuals with disabilities. Adhering to established standards like the Web Content Accessibility Guidelines (WCAG) is essential for creating inclusive and equitable learning experiences (W3C, 2018). A foundational step is using semantic HTML and ARIA landmarks to structure content clearly, enabling screen readers to interpret and navigate it effectively

(W3C, 2018). This includes proper heading hierarchies and role assignments that guide assistive technologies.

Equally important is keyboard accessibility all interactive elements such as buttons, forms, and menus should be fully operable using only a keyboard, with no “keyboard traps” that hinder navigation (W3C, 2018). To support users with visual or auditory impairments, text alternatives must be provided for all non-text content. This includes descriptive alt text for images and charts, as well as captions and transcripts for video and audio materials (W3C, 2018).
Maintaining high-contrast color schemes and using legible fonts ensures readability for users with low vision or color blindness (W3C, 2018). A responsive design approach guarantees that content adapts seamlessly to various screen sizes and orientations, which is especially helpful for users who rely on zoom or larger text settings (W3C, 2018). Additionally, offering adjustable text sizes and customization options such as font scaling, color themes, and playback speed empowers users to tailor the experience to their needs (CAST, 2018).

Interactive elements like quizzes and simulations must also be accessible, with clear instructions, compatibility with screen readers, and no unnecessary time constraints (W3C, 2018). Providing multiple formats for content such as PDFs, HTML, accessible ePub files, and translated versions ensures that learners can engage with material in the way that suits them best (CAST, 2018; W3C, 2018). To maintain high accessibility standards, regular testing and audits are vital (W3C, 2018). This includes using automated tools like WAVE or axe, as well as manual testing with users who rely on assistive technologies. Most importantly, accessibility should be integrated from the start of the design process, not added as an afterthought. Embracing Universal Design for Learning (UDL) principles helps ensure that the app accommodates a wide range of learning preferences and abilities, fostering a truly inclusive educational environment (CAST, 2018).

2.11 User-Centered Design (UCD) and Human-Computer Interaction (HCI)

Human-Computer Interaction (HCI) is an interdisciplinary field focused on designing, evaluating, and implementing interactive computing systems that align with human needs (ISO, 2019). Drawing from disciplines like computer science, psychology, cognitive science, and design, HCI aims to create intuitive, efficient, and accessible interfaces. It emphasizes

usability, user experience (UX), accessibility, and the broader cognitive and social impacts of technology.

Within this framework, User-Centered Design (UCD) serves as a practical, iterative methodology that places users at the heart of the development process (ISO, 2019). Rather than prioritizing technology or business goals alone, UCD focuses on understanding users' behaviors, goals, and contexts to design solutions that are both usable and meaningful. It applies principles from human factors, ergonomics, and usability research to ensure that systems meet real user needs.

The relationship between HCI and UCD is deeply interconnected. HCI provides the theoretical foundation and research tools for understanding how people interact with technology, while UCD translates these insights into actionable design practices (ISO, 2019). Together, they form a powerful approach to creating effective, user-friendly systems especially valuable in educational technology, where learner engagement and accessibility are paramount.

2.12 Core Concepts of User-Centered Design (UCD) in Educational Applications

Applying UCD to educational technology is essential, as both learners and educators bring unique needs, cognitive processes, and goals to the table (ISO, 2019). A foundational principle is an early focus on users and tasks, which involves understanding the learner's age, prior knowledge, learning styles, and digital literacy. For teachers, it means grasping their pedagogical methods and comfort with technology. It's also important to analyse the learning context whether the app will be used in class, for homework, or in low-connectivity environments and to break down educational goals into specific user tasks, such as completing coding challenges or tracking student progress.Empirical measurement and testing guide design decisions through data rather than assumptions (ISO, 2019). Usability metrics like task completion rates and error frequency provide objective insights, while interviews, surveys, and observations offer qualitative feedback on user satisfaction and pain points.UCD is inherently iterative, emphasizing continuous improvement through cycles of prototyping, testing, and refinement (ISO, 2019). Rapid prototyping ranging from sketches to interactive mock-ups allows teams to gather early feedback and adapt designs based on real user experiences. This

is especially important in education, where learning experiences are highly subjective and context-dependent.

A holistic user experience (UX) goes beyond usability to include emotional responses, aesthetics, and perceived value (Norman, 2013). For educational apps, UX directly impacts engagement and motivation. Even a usable app may fail if it's uninspiring or frustrating. A strong UX supports cognitive processes, reduces unnecessary mental load, and enhances learning outcomes.

2.13 Involving Users in the Design Process

Engaging students and teachers throughout the development lifecycle ensures the final product aligns with their real-world needs (ISO, 2019). During the requirements gathering phase, interviews, surveys, and focus groups uncover user goals and frustrations. Contextual inquiries observing users in their natural environments reveal behaviors and needs that might not surface in conversation. Personas, such as "student 1" or "student 2," help the team stay grounded in user realities.

In the design and prototyping phase, co-design workshops empower users to contribute ideas and sketch solutions. Techniques like card sorting and tree testing help shape intuitive navigation, while wireframe reviews provide early feedback on layout and flow.

Finally, the evaluation phase involves usability testing, where users interact with prototypes while thinking aloud to reveal their thought processes (ISO, 2019). A/B testing compares different design versions in real-world use, while analytics track engagement and identify friction points. Beta testing with a small group of users offers final validation before full deployment.

Usability Evaluation Methods in Educational App Design

Usability evaluation is a cornerstone of User-Centered Design (UCD), ensuring that educational applications are not only functional but also intuitive, efficient, and satisfying to use (ISO, 2019). Two widely adopted methods are Usability Testing and Heuristic Evaluation, each offering unique strengths.

Usability Testing is considered the gold standard (ISO, 2019). It involves observing real users such as students or teachers interacting with a prototype or product to complete realistic tasks. Participants are carefully selected to reflect the target audience, and tasks are designed to mirror actual use cases (e.g., locating a tutorial or creating a quiz). During the session, facilitators observe user behaviour, record verbal feedback (often using the think-aloud method), and

collect both qualitative and quantitative data, such as task completion rates and error frequency. This method provides rich insights into user behaviour and uncovers unexpected usability issues, though it can be time-consuming and resource-intensive.

In contrast, Heuristic Evaluation is an expert-driven approach where usability specialists assess the interface against established principles most commonly Nielsen's 10 Usability Heuristics (Nielsen, 1994). These include guidelines such as maintaining system visibility, using familiar language, ensuring user control, and designing for error prevention and recovery. Experts independently review the interface, then consolidate their findings to identify usability flaws. This method is faster and more cost-effective than user testing and can be conducted early in the design process. However, it relies on expert judgment and may overlook issues that only emerge during real-world use.

Together, these methods provide a comprehensive view of usability combining user insights with expert analysis to guide iterative improvements and ensure that educational apps are both effective and user-friendly.

2.14 Gamification in Education: Theories, Motivation, and Effective Features

Gamification in education involves integrating game-like elements into non-game contexts to enhance engagement, motivation, and learning outcomes. It taps into fundamental human drives achievement, mastery, social connection, and progress making learning more interactive and rewarding (Deterding et al., 2011).

Several psychological theories explain why gamification is effective. Self-Determination Theory (SDT) posits that motivation flourishes when three core needs are met: autonomy (having control and choice), competence (feeling capable and effective), and relatedness (feeling connected to others). Gamified learning environments support these needs through customizable tasks, immediate feedback, and social features like leader boards and team challenges, fostering intrinsic motivation and sustained engagement (Deci & Ryan, 2000).

John Keller's ARCS Model further explains how gamification captures and maintains learner motivation. It emphasizes attention (through novelty and surprise), relevance (by connecting content to real-world goals), confidence (via achievable challenges and progress tracking), and satisfaction (through rewards and visible accomplishments). These elements align closely with gamified systems that provide structured feedback and a sense of achievement (Keller, 1987).

From a behaviorist perspective, gamification leverages positive reinforcement using points, badges, and rewards to shape desired behaviors. These rewards activate the brain's dopamine system, creating a positive association with learning tasks (Skinner, 1953). Social Learning Theory also plays a role, as learners observe and emulate peers through collaborative challenges and public recognition, fostering a sense of community (Bandura, 1977). Meanwhile, Flow Theory explains how gamification sustains deep engagement by balancing challenge and skill, keeping learners in a state of focused immersion (Csikszentmihalyi, 1990). Common gamification features reflect these theories in action. Badges serve as visual markers of achievement, offering recognition, guiding progress, and even acting as micro-credentials. They fulfil the need for competence and can boost motivation though overuse may risk shifting focus from learning to reward collection (Hamari et al., 2014). Levels provide structured progression, breaking content into manageable stages and increasing difficulty over time. This supports cognitive development, maintains engagement, and aligns with flow by matching challenge to skill (Zichermann & Cunningham, 2011).

Leaderboards introduce social comparison and competition, motivating learners to improve and benchmark their progress. When thoughtfully designed, they can increase participation and foster a sense of accomplishment. However, they must be used carefully to avoid discouraging lower-ranked learners (Koivisto & Hamari, 2014).Together, these features grounded in well-established motivational theories demonstrate how gamification can transform educational experiences into dynamic, learner-centered journeys.

2.15 Cognitive and Pedagogical Theories in Programming Education

Learning programming goes far beyond mastering syntax it involves cultivating problem-solving skills, logical reasoning, and the ability to think abstractly. Several learning theories offer insights into how this process unfolds. Cognitive Learning Theory focuses on mental processes like memory, perception, and problem-solving. In programming, it emphasizes how learners internalize concepts such as algorithms and program flow. Metacognitive strategies, building mental schemas, and teaching general problem-solving techniques are commonly used approaches (Sweller, 1988).

Behaviorism, although less dominant today, still informs early skill acquisition. Positive reinforcement such as rewards for correct syntax or successful code execution strengthens

desirable behaviors, laying a foundation for more complex learning (Skinner, 1953). Social Cognitive Theory (Bandura, 1977) underscores learning through social interaction and observation. In programming, this translates to pair programming, peer collaboration, observing skilled coders, and fostering self-efficacy through support and shared success.Constructivist Learning Theories are especially influential in programming education. At their core is the belief that learners actively construct understanding. Learning is personal, active, and often social driven by engagement and motivation. Cognitive Constructivism (Piaget, 1950) emphasizes individual discovery, where learners grasp programming concepts through hands-on experimentation. Social Constructivism (Vygotsky, 1978) focuses on cultural and interpersonal learning, with the Zone of Proximal Development suggesting learners excel when guided by more experienced peers. These frameworks encourage approaches like inquiry-based, problem-based, and project-based learning. Debugging, collaboration, and reflection are vital practices (Kafai & Burke, 2013).

2.16 Cognitive Load Theory

Cognitive Load Theory (Sweller, 1988) is central to designing effective programming tools and apps. It categorizes cognitive effort into three types:

i. Intrinsic Load relates to task complexity (e.g., recursion vs. basic output). Well-designed content scaffolds this by sequencing topics from simple to complex.
ii. Extraneous Load stems from poor design. Reducing this involves streamlining interfaces, minimizing redundancy, and aligning visuals with instructions.
iii. Germane Load is productive effort that supports deep learning. Interactive examples, visualizations, adaptive content, and opportunities for self-explanation boost schema development (Sweller et al., 2019).

Scaffolding and Personalized Learning round out effective pedagogy. Drawing from Vygotsky (1978), scaffolding offers temporary support like code templates, guided tutorials, and context-sensitive hints which gradually fades as learners gain confidence. Meanwhile, personalized learning adapts to each learner's pace, style, and goals. This includes diagnostic assessments, tailored pathways, learner analytics, and immediate feedback, all geared toward meaningful, self-directed progress (Popenici & Kerr, 2017).

2.17 Challenges in Teaching Programming to High School Students

Despite growing recognition of programming as essential for digital literacy, its instruction in high schools faces notable hurdles. One major issue is the abstract nature of programming concepts, which introduce unfamiliar logical structures and computational thinking. This cognitive leap, combined with complex syntax and semantics, often causes frustration, poor motivation, and even course withdrawal (Grover & Pea, 2013). Many students also lack foundational skills in discrete math or logic, making it hard to design programs or grasp control structures.Teacher preparedness is another critical challenge. Educators frequently lack specialized training or effective teaching strategies, often relying on static materials that fail to make programming dynamic and engaging (Guzdial, 2015). Large class sizes further limit individual support and timely feedback, deepening student struggle.

2.18 Misconceptions and Barriers to Learning

Misunderstandings about programming are widespread. Students may think code executes non-sequentially, or misinterpret assignment direction and variable behavior. Many believe the computer can infer intent or misjudge loop and conditional logic assuming, for example, both branches of an if-else statement might execute, or that loops restart on false conditions. Other common misconceptions include confusion around input/output (e.g., assuming printed output changes variable values). These stem from inadequate mental models and are worsened by weak problem-solving skills, limited abstract reasoning, and a lack of self-regulated learning strategies (Robins et al., 2003). Early failures often lead to low self-efficacy and negative attitudes, reinforcing disengagement.

2.19 Motivation and Engagement

Motivation is pivotal. Intrinsically motivated students find programming enjoyable or intellectually stimulating, valuing autonomy, mastery, and challenge. Extrinsic motivators like grades, recognition, or career relevance also play a role. Self-efficacy belief in one's capability to succeed—and perceived utility of programming can influence persistence (Bandura, 1997). To enhance engagement, schools can implement project-based learning (apps, games, websites), game-based elements, and real-world context. Tools like Scratch or block-based environments reduce syntax frustration and allow focus on logic (Grover & Pea, 2013). Offering choice, providing scaffolding (hints, templates, step-by-step prompts), and ensuring

quick, meaningful feedback are crucial. Coding competitions and challenges further foster motivation and a sense of accomplishment (Malan & Leitner, 2007).

2.20 The Role of Peer Collaboration

Social learning, as per Bandura (1977), supports deeper understanding and motivation. Peer collaboration through pair programming, group projects, or code reviews encourages dialogue, builds confidence, and distributes cognitive load. It also sharpens communication skills and exposes students to diverse approaches. Online forums and class communities extend this collaboration, nurturing continuous learning beyond the classroom (Kafai & Burke, 2013).Effective Feedback in Educational Apps: Formative and Summative ApproachesFeedback plays a central role in enhancing student learning, and educational apps are uniquely positioned to deliver timely, personalized, and actionable responses that support growth (Elmahdi et al., 2018; Vartiainen et al., 2016). By leveraging technology's immediacy and adaptability, these platforms go beyond traditional assessment models to guide both learning and reflection.

Formative feedback, provided during the learning process, is aimed at fostering improvement and reinforcing understanding (Black & Wiliam, 1998a; Shute, 2008). One of its key strengths in digital applications lies in its immediacy apps can offer instant responses that help learners address misconceptions before they become ingrained (Riddell, 2015; ERIC, 2018). Such feedback should go beyond binary correct/incorrect indicators and instead provide rich explanations, relevant hints, or worked examples to guide learner understanding (Shute, 2008; Hattie & Timperley, 2007). Moreover, the tone of feedback is important; it should be non-evaluative and supportive, aiming to build self-efficacy and encourage a growth mind set (Poorvu Center, n.d.; Yopp & Rehberger, 2009).

Well-integrated feedback within learning activities such as mini-quizzes, simulations, or interactive tasks makes the experience more cohesive and purposeful. Multimodal delivery through text, audio, visuals, or video ensures that feedback accommodates diverse learner preferences (Narciss, 2008). Furthermore, effective apps encourage revision by offering multiple attempts or scaffolder support, allowing students to re-engage with content and apply what they have learned (Poorvu Center, n.d.). Transparency is equally important: clear learning objectives and success criteria, often through rubrics, help students track progress and align efforts with expectations.

Summative feedback, typically delivered at the end of an instructional unit, evaluates overall performance and achievement (Poorvu Center, n.d.). Educational apps enhance the summative experience through comprehensive analytics dashboards that highlight student strengths and weaknesses across content areas. Data visualizations such as graphs and heat-maps make patterns more accessible, while comparative feedback showing class averages or performance benchmarks anonymously can motivate learners to set personal goals (Kahu, 2013). Automated grading systems efficiently assess objective tasks like multiple-choice questions (SkoolBeep, n.d.; Trootech, 2023), while integrated digital rubrics ensure consistency and clarity for more complex submissions, supporting self- and peer assessment alongside instructor evaluation.

Beyond standard feedback models, adaptive learning systems introduce a high degree of personalization by continually analysing learner data and adjusting content accordingly (Hyperspace, n.d.; AiCoursify, 2024). These systems rely on data-driven insights tracking errors, time spent, and engagement metrics to tailor the feedback process (Jobillico, 2023; Hyperspace, n.d.). Dynamic, individualized learning paths allow students to explore content at their own pace, with targeted remedial or advanced tasks when appropriate (AiCoursify, 2024). A standout benefit of adaptive feedback is its timing and relevance; "just-in-time" responses ensure that learners receive the right support at the right moment, optimizing cognitive processing without overwhelming working memory (Popenici & Kerr, 2017). Additionally, advanced platforms integrate predictive analytics to proactively flag areas where learners are likely to struggle, offering guidance before errors occur (eLearningIndustry, 2024). Adaptive assessments adjust question difficulty based on previous performance, ensuring that feedback remains both level-appropriate and targeted (Hyperspace, n.d.). These systems often compile learner profiles incorporating study habits, preferences, and performance history, allowing them to recommend resources and strategies aligned with students' needs (Whatfix, 2023). Many also include metacognitive feedback prompts, which ask students to reflect on their learning strategies or explain their reasoning supporting self-regulation and deeper comprehension (Narciss, 2008).

Finally, gamified feedback elements such as points, badges, and leaderboards can further enhance motivation and engagement by turning assessment into a rewarding and interactive experience (Jobillico, 2023). Altogether, these strategies illustrate how effective feedback in

educational apps both formative and summative can empower students, personalize learning, and drive deeper, more sustained educational outcomes.

2.21 Existing Research on the Impact of Educational Apps

The widespread adoption of mobile devices has sparked growing interest in their educational potential, particularly within computer science education. Research generally indicates positive impacts, though effectiveness often hinges on app design quality, integration into pedagogy, and learner context. In computer science programs, mobile learning applications have been shown to enhance students' academic achievement and motivation, especially when used to support animation development, coding practice, and interactive problem-solving tasks (Demir & Akpinar, 2018). Educational apps that incorporate gamification, adaptive feedback, and interactive simulations are particularly effective in fostering deeper engagement and conceptual understanding in programming and computational thinking (Griffith et al., 2020; Outhwaite et al., 2022)2. Moreover, the integration of mobile apps into computer science curricula aligns well with the discipline's emphasis on technology-driven learning environments. However, disparities in access, digital literacy, and instructional design can limit their effectiveness. Therefore, aligning app use with curriculum goals and ensuring equitable access is essential to maximize their educational value in computer science contexts.

2.22 Learning Outcomes and Academic Performance

Many studies report improved academic performance among students using educational apps, with higher test scores and better concept mastery compared to traditional methods (YouLearnt, 2024; AEP Awards, n.d.). For example, digital educational games have been linked to significantly higher final exam scores (Sung et al., 2016). Additionally, apps help develop essential 21st-century skills digital literacy, analytical thinking, and problem-solving—while providing real-world, tech-integrated learning environments (AEP Awards, n.d.; Kebritchi et al., 2017; University at Buffalo, n.d.).

2.23 Accessibility, Flexibility, and Personalization

Educational apps offer anytime-anywhere access, making learning more continuous and inclusive—especially for students with irregular schedules, disabilities, or those in remote areas (YouLearnt, 2024; UNESCO, 2017). This increased accessibility supports distance learning and helps bridge educational gaps by removing geographical and temporal barriers. Features such as screen readers, adjustable text sizes, and offline functionality further enhance usability

for diverse learners, promoting equity in education. Flexibility is another key advantage, allowing students to engage with content at their own pace and revisit challenging concepts as needed. This is particularly beneficial for adult learners, working professionals, and students balancing multiple responsibilities2. Moreover, many apps now employ adaptive learning algorithms that tailor content to individual learning styles, progress, and preferences—boosting engagement, retention, and academic performance (YouLearnt, 2024; Chen et al., 2019; Forbes, 2023). By combining these elements, educational apps are reshaping traditional learning models into more student-centered, responsive experiences that accommodate a wide range of needs and contexts.

2.24 Mixed Findings and Cautions

Despite overall benefits, some studies advise caution. A meta-analysis of mobile-assisted language learning apps found positive impacts but noted methodological concerns, such as high bias risk and uneven evidence quality (Christenson et al., 2016). Another study suggested that while apps are widely used, their academic impact can vary, underscoring the importance of deep engagement (Periodicals of Engineering and Natural Sciences, 2025). Over-reliance without pedagogical depth may hinder effectiveness (AEP Awards, n.d.).

2.25 Motivation and Engagement

Educational apps consistently boost motivation and engagement. Interactive interfaces, multimedia content, and gamified features increase enjoyment and focus (YouLearnt, 2024; ResearchGate, 2024). Gamification via badges, points, and progress tracking—transforms routine learning into rewarding experiences (PMC, 2021). Real-time feedback helps students monitor progress and celebrate successes (YouLearnt, 2024), while learner autonomy through content choice and pacing supports intrinsic motivation (Jurnal Nawala, n.d.; ResearchGate, 2025). Apps often simulate real-world contexts to deepen engagement (ResearchGate, 2024) and integrate peer interaction for social reinforcement (PMC, 2021).

2.26 Successful Case Studies

Duolingo uses gamified, bite-sized lessons and instant feedback to drive language learning engagement (Jurnal Nawala, n.d.). Khan Academy delivers personalized dashboards, instructional videos, and mastery-based progression, enabling self-paced, effective learning (AiCoursify, 2024). "Jill Watson" (Georgia Tech), an IBM Watson-powered AI TA, enhanced online course support by answering frequent student queries, reducing human workload

(DigitalDefynd, 2025). Maths Pathway (Australia) customizes math learning based on real-time progress, using adaptive AI to personalize modules and feedback (DigitalDefynd, 2025). Noah Education (China) integrates devices and learning software (e.g., nFlashMX, NTrack) to support a tech-rich learning experience (ResearchGate, 2010). University of ABC improved engagement and retention via a robust LMS, enhanced with teacher training and asynchronous access (Medium, 2023). XYZ School District adopted a blended learning model using LMS tools to streamline content delivery, communication, and reduce absenteeism (Medium, 2023).

2.27 Literature Review on Existing Educational Apps and Tools: Gaps and Opportunities

The rise of mobile devices and widespread digital literacy has transformed educational landscapes, giving rise to a diverse ecosystem of educational apps and tools. These range from structured e-learning platforms to gamified mobile apps, supporting learners of all ages, abilities, and learning styles. Popular content delivery platforms such as Coursera, edX, Udemy, and Khan Academy provide video lectures, interactive exercises, and assessments across academic and professional domains. Khan Academy stands out for its global reach and free, self-paced resources, making quality education broadly accessible (YouLearnt, 2024). Similarly, digital textbooks and e-readers like Kindle and Google Play Books enhance content consumption with annotation tools and interactive features.

Language learning apps such as Duolingo, Babbel, and Rosetta Stone leverage gamification, spaced repetition, and short practice modules to make vocabulary acquisition engaging and effective. Duolingo, in particular, is lauded for its appealing design and gamified progression system (Jurnal Nawala, n.d.). In the domain of interactive learning, apps like Quizlet and Kahoot! incorporate game mechanics to increase motivation through points, badges, and leaderboards. Additionally, simulation tools such as PhET Interactive Simulations allow learners to manipulate scientific variables and conduct virtual experiments, while coding apps like ScratchJr and Swift Playgrounds offer block-based or guided tutorials to introduce programming fundamentals (Grover & Pea, 2013).

Apps also support classroom management and assessment. Tools like Google Forms, Socrative, and Mentimeter enable real-time polling and feedback collection. For productivity, Evernote, OneNote, and Notion help students organize notes and tasks, while collaboration platforms like

Google Workspace and Microsoft 365 facilitate teamwork through shared documents and communication tools. Furthermore, specialized apps serve students with learning differences and disabilities by offering screen readers, focus aids, or simplified interfaces. Apps focused on mental wellness, such as mindfulness and stress reduction tools, while not strictly educational, enhance learning indirectly by supporting emotional health.

Despite this rich variety, several gaps remain. A key area for development lies in adaptive learning. While many apps claim adaptivity, most only react to quiz performance, adjusting content superficially. Opportunities exist to implement advanced artificial intelligence for deeper personalization diagnosing misconceptions, predicting future challenges, and offering individualized pedagogical strategies (Chen et al., 2019). AI tutors could simulate nuanced, conversational instruction and even incorporate emotional intelligence to detect user frustration and adapt accordingly.

Another significant shortcoming is the quality of formative feedback. Most apps offer binary right/wrong judgments, lacking contextual explanations that help students understand errors and reflect on their reasoning (Narciss, 2008). Embedding metacognitive prompts, facilitating peer feedback, and offering richer dashboards that visualize persistent difficulties could enhance learning outcomes. Furthermore, the divide between formal education and informal exploration remains a challenge. While many apps support school curricula and others focus on hobbies, few bridge the two seamlessly. Opportunities exist in developing platforms for project-based learning, immersive AR/VR experiences, and citizen science initiatives that blend inquiry, creativity, and curriculum goals.

Digital accessibility also remains uneven. Learners in low-resource settings often face limitations in internet access, devices, or cultural relevance of content. Designing apps that function offline, consume minimal data, and incorporate inclusive design would address these issues. Localization efforts should move beyond simple translation to include culturally sensitive examples and adaptive visuals (Tlili et al., 2020).

Finally, integration with teacher workflows is a persistent hurdle. Many apps generate valuable student data that remains siloed or difficult to act upon. Teachers often juggle multiple platforms, leading to inefficiencies and fragmented insights. The development of interoperable systems, unified teacher dashboards, and AI-driven analytics that recommend targeted

interventions could greatly enhance educator effectiveness (Verbert et al., 2014). Moreover, expanding automated grading capabilities to include open-ended tasks like essays or code supported by teacher review would reduce administrative load and provide faster, richer feedback.

In sum, while the educational app ecosystem is broad and increasingly sophisticated, meaningful opportunities remain to elevate their pedagogical value. By advancing personalization, feedback quality, accessibility, and integration, developers and educators can unlock the full potential of these tools to transform learning experiences for diverse student populations.

3 Chapter 3: Requirements Analysis

This chapter details the systematic process of gathering, analysing, and documenting the requirements for the mobile application designed to enhance programming skills among high school students. A user-cantered approach was adopted to ensure the application directly addresses the needs and preferences of its target users, thereby maximizing its usability and educational effectiveness.

3.1 Needs Assessment: Surveys and Interview Results

To gain a comprehensive understanding of the challenges faced by high school students in learning programming and their preferences for a mobile learning tool, a mixed-methods approach was employed, combining surveys and semi-structured interviews.

Surveys: Anonymous online surveys were distributed to a sample of high school students (N=20) currently taking or interested in programming, as well as high school computer science teachers (N=5). The surveys aimed to gather quantitative data on:

a. Current learning methods: Frequency of using textbooks, online tutorials, in-person classes, and existing mobile apps.
b. Perceived difficulties: Specific programming concepts found most challenging (e.g., debugging, abstract concepts, syntax).
c. Motivational factors: What makes learning engaging or disengaging.
d. Feature preferences: Desired functionalities in a programming learning app (e.g., interactive exercises, gamification, personalized feedback, code editors).
e. Mobile app usage habits: Frequency of mobile app use for educational purposes, preferred device types.

Interview Results: Semi-structured interviews were conducted with a smaller subset of students (N=20) and teachers (N=5). These interviews provided qualitative insights, allowing for deeper exploration of survey responses and uncovering nuances. Key themes emerging from the interviews included:

a. Lack of immediate feedback: Students often struggled to identify errors and understand why their code wasn't working, leading to frustration.
b. Abstractness of concepts: Difficulty in visualizing how programming concepts translated into real-world applications.
c. Monotony of traditional methods: Text-heavy resources and lecture-based learning were often perceived as boring and ineffective.

d. Desire for practical application: A strong wish for more hands-on coding exercises and project-based learning.
e. Importance of personalized pace: Students expressed a need to learn at their own speed, without feeling rushed or held back.
f. Teacher perspectives: Teachers highlighted the challenge of catering to diverse learning paces in a classroom setting and the need for supplementary tools.
g. Technical limitations: Some students lacked access to powerful computers or reliable internet, making mobile accessibility crucial.

3.2 Target Audience Profile

Based on the needs assessment, a detailed profile of the target audience was developed:

i. Demographics: High school students (ages 14-18), both male and female, from various socio-economic backgrounds.
ii. Technology Proficiency: Generally, tech-savvy, comfortable with smartphones and mobile applications for various purposes (social media, entertainment, some educational apps).
iii. Programming Background: Ranging from complete beginners with no prior programming experience to those with basic exposure.
iv. Learning Styles: A mix of visual learners, kinesthetic learners (learning by doing), and auditory learners, necessitating diverse content delivery methods.
v. Motivation: Seeking engaging and interactive ways to learn, motivated by challenges, progress tracking, and peer recognition. Easily discouraged by complex, unengaging content.
vi. Goals: To understand fundamental programming concepts, develop problem-solving skills, and gain confidence in writing code. Some may be considering a career in computer science.
vii. Constraints: Limited time due to academic commitments and extracurricular activities. Access to reliable internet and suitable devices can vary.

3.3 Functional and Non-Functional Requirements

The requirements for the mobile application were categorized into functional (what the system does) and non-functional (how well the system performs).

Functional Requirements (FRs):

i. User Registration and Profile Management: Allow users to create accounts, manage profiles. and set learning goals.
a. Interactive Learning Modules: Provide structured lessons on core programming concepts (e.g., variables, loops, conditionals, functions).

b. Code Editor and Compiler: Enable users to write and execute code snippets directly within the app, with immediate feedback on errors.
c. Interactive Exercises and Quizzes: Offer a variety of practice problems, coding challenges, and multiple-choice quizzes to reinforce learning.
d. Gamification Elements: Incorporate badges, points, levels, leaderboards, and progress tracking to motivate users.
e. Personalized Learning Paths: Adapt content and difficulty based on user performance, learning pace, and expressed preferences.
f. Instant Feedback Mechanism: Provide clear, constructive feedback on code errors, quiz answers, and exercise submissions.
g. Progress Tracking and Analytics: Display user progress, completed tasks, scores, and areas needing improvement.

3.4 Non-Functional Requirements (NFRs):

i. Usability: The application must be intuitive, easy to navigate, and have a clear, consistent user interface. (High priority)
ii. Performance: The app should load quickly, execute code efficiently, and respond promptly to user interactions.
iii. Reliability: The app should function consistently without crashes or data loss.
iv. Security: User data and progress information should be securely stored and protected.
v. Portability: The application should be compatible with Android and IOS mobile platforms.
vi. Accessibility: Design considerations for users with diverse needs (e.g., clear fonts, color contrast, alternative text).
vii. Maintainability: The codebase should be well-structured and documented for future updates and bug fixes.
viii. Engagement: The design should foster sustained user interest and motivation.

3.5 Key Features and Features Prioritized

Based on the needs assessment and requirements analysis, the following key features were identified and prioritized:

High Priority Features (MVP - Minimum Viable Product):

a. Interactive Code Editor with Real-time Feedback: This is paramount for immediate error correction and understanding.

b. Structured Learning Modules: Progressive lessons covering fundamental programming concepts.
c. Gamified Progress Tracking: Points, badges, and a visual representation of progress to maintain motivation.
d. Basic Interactive Exercises: Simple coding challenges, quizzes and interactive games.
e. Personalized Difficulty Adjustment: The ability to present challenges appropriate to the user's current skill level.
f. Clear Explanations and Examples: Concise and easy-to-understand explanations of concepts.

Medium Priority Features:

g. Advanced Gamification: Leaderboards, streaks, and more complex challenges.
h. Project-Based Learning: Small, guided projects to apply learned concepts.
i. Comprehensive Resource Library: Curated external links, official documentation snippets.
j. Peer Collaboration/Forum: A platform for students to ask questions and help each other.
k. Adaptive Learning Paths: More sophisticated algorithms for tailoring content based on detailed performance analytics.

3.6 Low Priority Features (Future Considerations):

I. AI-Powered Tutoring/Hint System: More intelligent assistance for debugging.
II. Augmented Reality (AR) or Virtual Reality (VR) Elements: Immersive learning experiences.

User Personas and Scenarios

To further empathize with the target users and ensure the design caters to their specific needs and behaviors, several user personas were developed. These personas represent archetypical users of the mobile application.

I. User Persona 1: "Aspiring Programmer student 1"

Age: 16

a. Background: Currently in her second year of high school. Has a strong interest in technology and gaming but no formal programming experience. Finds textbooks dry.
b. Goals: Wants to learn the basic of writing a code. Hopes to pursue computer science in college.

c. Challenges: Gets easily frustrated when code doesn't work, needs clear explanations, prefers visual learning and hands-on practice. Limited access to a powerful computer at home.
d. Mobile App Usage: Uses her smartphone frequently for social media, YouTube, and some educational apps for other subjects.
e. Scenario: Alice downloads the app. She starts with the "Introduction to Variables" module. She struggles with a coding exercise, but the app provides an immediate, helpful hint, allowing her to correct her code and earn points. She then watches a short animated explanation of variables before moving to the next concept.

II. User Persona 2: "Struggling Learner student 2"

Age: 15

I. Background: Required to take an introductory programming course at school. Finds programming concepts abstract and difficult to grasp. Often falls behind in class.
II. Goals: Pass his programming class. Wants to understand the basics without feeling overwhelmed.
III. Challenges: Easily loses motivation if he doesn't see progress. Needs concepts broken down into very small, manageable chunks. Prefers quizzes and quick feedback.
IV. Mobile App Usage: Uses his phone for entertainment, less frequently for education unless it's engaging.
V. Scenario: student 2 uses the app to supplement his classroom learning. He appreciates the bite-sized lessons and the immediate feedback on quizzes. The app's personalized path detects his areas of weakness and provides extra practice exercises specifically targeting those concepts, helping him build confidence.

User Persona 3: "Teacher"

Age: 45

I. Background: Experienced high school computer science teacher. Uses a mix of lectures, textbook exercises, and online resources.
II. Goals: Find supplementary tools that can help students learn at their own pace, provide extra practice, and motivate them outside of class.
III. Challenges: Large class sizes make personalized attention difficult. Students have varying levels of prior knowledge and learning speeds.
IV. Mobile App Usage: Uses educational apps for classroom management and finding resources.
V. Scenario: Teacher recommends the app to his students for extra practice and remediation. He appreciates that the app covers fundamental concepts and

provides immediate feedback, allowing students to learn independently and freeing up his time to focus on more complex topics in class.

Table 3:1 Persona-Driven Educational Design

Persona	Need	Design Response
Student1	Visual learning	Animated tutorials
Student 2	Quick feedback	Quizzes, personalised paths
teacher	Creating content	Uploading content

These personas and scenarios will serve as guiding principles throughout the design and development phases, ensuring that the application remains centered on the actual needs and experiences of its intended users.

The insights gathered through surveys, interviews, and user personas reveal the diverse needs, motivations, and challenges of high school students and educators in the programming education landscape. These findings provide a crucial foundation for the design phase, ensuring that every interface element, feature, and user interaction is purposefully crafted to meet real-world demands. Chapter 4 builds directly upon these user-centered insights to shape an intuitive, accessible, and engaging mobile application.

4 Chapter 4: Design Phase

The design phase translates the insights from requirements analysis into a tangible, intuitive, and inclusive mobile learning experience. Our goal is to create an app that not only enhances programming skills but also engages and motivates high school students across diverse contexts and devices.

4.1 Design Goals and Principles

Our design approach is guided by the following principles:

Simplicity and Clarity: Clean layouts, intuitive icons, and plain language reduce cognitive load and make programming concepts more accessible.

Engagement and Motivation: Gamification, progress tracking, and real-world coding challenges foster sustained interest.

Personalization and Adaptability: Customizable learning paths, difficulty levels, and UI settings support diverse learner needs.

Consistency: Uniform visual and interaction patterns ensure predictability and ease of use.

Accessibility: WCAG 2.1 compliance, screen reader support, and adjustable UI elements make the app inclusive.

Feedback and Support: Real-time feedback, hints, and contextual help empower learners to learn from mistakes and persist.

4.2 Wireframes, UI Prototypes, and Feature Definition

Low-fidelity wireframes will outline:

Information Architecture: Logical grouping of questions/exercises, and user data.

Screen Layouts: content zones and interactive elements.

User Flows: Quiz progression, and quiz completion.

Table 4:1: Key screens

Screen Name	Purpose
Login Profile	Allows users to securely sign in, manage personal settings, and track progress.
Notes	Provides a space for learners to create, organize, and review study materials.
quizzes	Offers interactive assessments to test knowledge, provide feedback, and reinforce learning.
Challenges	Presents time-bound or skill-based tasks to motivate learners and promote mastery.
Games	Delivers engaging, gamified learning experiences to enhance retention and enjoyment.

Task Design: ProgQuest Interface Navigation

The app makes use of GUI, Fidelity prototypes, interactive elements such as B**uttons and links.** The app will be used by learners who are at different stages of technology proficiency whose needs should be catered for. Bearing in mind these users with different capabilities, the navigation design and rate of the screens was considered in task Design.

Task 1: Navigation Design

Objective
Improve first-time user navigation rate: Increase the likelihood that new users can find and select the desired option on their first attempt.

Constraints

- **Clickable affordance**: Every button or link must clearly indicate it is interactive (e.g., via visual affordances, hover states, and accessible touch targets).
- **Accessibility considerations**: Ensure keyboard and screen reader support (focus rings, descriptive ARIA labels, logical tab order).
- **Consistency**: Uniform button/link styles, spacing, and behaviour across the main menu.
- **Performance**: Minimal load times for rendering the main menu.
- **Mobile and desktop parity**: Interaction cues and hit targets scale appropriately across devices.

Deliverables

- **Interactive Buttons or Links**: A set of clearly labelled, tappable/clickable controls on the main menu screen.
    - Each control should have:
        - A concise label (e.g., “StartQuest”, “Next”, “Submit”).
        - A visible cursor.
- **Visual Design Notes**: Documentation of affordances and interactive states (default, hover/focus, active, disabled, enabled).
- **Prototype/Mockups**: High-fidelity mockups or a clickable prototype

Task 4:1 Navigation Design

4.2.1 High-fidelity prototypes

4.2.1.1 High-fidelity prototypes will incorporate:

Visual Design: Colour schemes, text, GUI as shown in Figure 4:1.

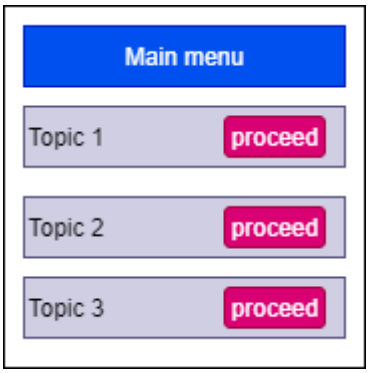
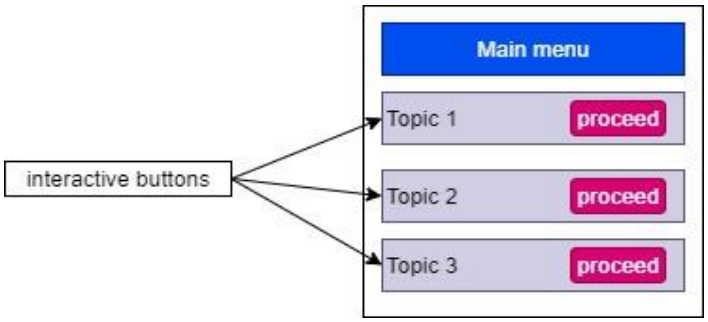


Figure 1 GUI of the main menu Screen

4.2.1.2 Interactive Elements

This is illustrated in Figure 4:2

Figure 2 Interactive Buttons on the main menu Screen



User navigation follow for ProgQuest

This diagram below illustrates the user journey within an ProgQuest platform, beginning with the login process and progressing through topic selection and personalized learning tools. Upon entering their credentials in the Log in section, users are directed to the Main Menu**,** where they can choose from multiple topics using clearly labelled "Start Topic" buttons. From there, they transition into the Profile hub, which offers access to key features like Notes, Quizzes, Games, and Challenges each represented with distinct colours for clarity. The Notes section, accessible both from the Profile and directly after login, includes a "Proceed" button that encourages forward navigation rather than backtracking. Arrows between each guide the user through a seamless, intuitive flow, ensuring that every step—from authentication to engagement is clearly mapped and easy to follow.

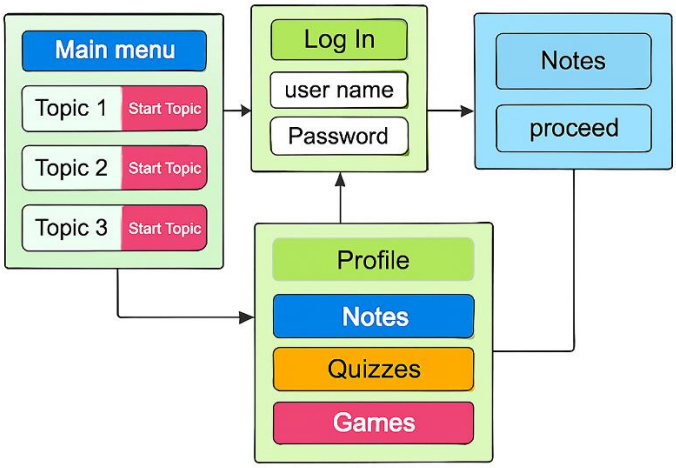


Figure 4:3 User navigation flow for ProgQuest 1

4.3 Feature Definition

Each feature will be defined with functionality and UX integration:

Peer discussion boards, collaborative coding, and shared challenges.

4.4 User Experience (UX) Considerations

To ensure a delightful and effective experience:

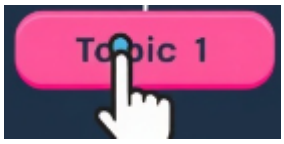
The platform offers a clear, learner-cantered experience through intuitive navigation and modular design. Arrows and labelled buttons guide users smoothly from login to learning activities, minimizing confusion. Pastel colour coding and consistent button styles enhance visual clarity. Quizzes are accessible via both Notes and Profile, supporting active recall and flexible learning paths. The secure Log In ensures personalized access, while modular sections like Main Menu and Profile allow for scalability and responsive design. Learners have control over their journey, choosing when to review notes or test understanding. High-contrast text and simple labels support accessibility across diverse user groups.

4.5 Interaction Design

Main Menu

Direct Manipulation:

I. **Tap** on "Start Topic" buttons for each topic.
II. **Swipe** to navigate between topics if there are multiple screens



4.5.1 Interaction design

Log In

Direct Manipulation:

I. **Tap** on fields to enter "username" and "password."
II. **Tap** on the "Log In" button to submit credentials.

III. **Swipe** to reveal options for password recovery or new user registration.

Notes

Direct Manipulation:

I. **Tap** on a note to view or edit it.
II. **Drag** to reorganize notes.
III. **Swipe** to delete a note or access additional options.

Profile

Direct Manipulation:

I. **Tap** to edit profile information.
II. **Drag** to rearrange settings options.

Quizzes/Games

Direct Manipulation:

I. **Tap** to start a quiz or game.
II. **Swipe** to navigate between different quiz questions or game levels.

4.6 Navigation Design

The platform features a clear, modular navigation flow. Users begin at the Log In screen, then move to the Main Menu to select topics. From there, they access the Profile Hub, which offers tools like Notes, Quizzes, Games, and Challenges. Quizzes are reachable via both Profile and Notes, allowing learners to test understanding after reviewing content. Directional arrows and consistent button styles guide users smoothly, while the modular layout supports scalability and mobile responsiveness. The design promotes autonomy, clarity, and a focused learning experience.

4.7 Usability Testing Strategy

To validate design decisions:

Participants: Diverse group of students who are at different stages of technology proficiency

Methods 1:

Think-Aloud Protocol: Users verbalize thoughts while using the app. This would be used in testing the navigation rate of the ProgQuest main Menu Screen as shown in Figure ….

Remote Testing: Observe users via screen sharing tools.

Guerrilla Testing: Quick feedback from users in informal settings.

Metrics:

Task completion rate

Time on task

Error frequency

User satisfaction scores

Accessibility Enhancements

To ensure inclusivity:

WCAG 2.1 Compliance: Perceivable, operable, understandable, and robust design.

Adjustable UI: Font scaling, high contrast themes, and dark mode toggle.

Offline Access: Downloadable lessons and exercises for low-connectivity environments.

Device Compatibility

The app will support:

Platforms: Android 10 and IOS

Screen Sizes: Phones and tablets

By grounding our design process in evidence-based user needs and pedagogical principles, we have crafted a mobile learning experience that is not only functional but emotionally resonant and adaptable. The app's visual and interaction design promotes clarity, engagement, and inclusivity across devices and learning styles. As we transition into development, the wireframes, prototypes, and detailed feature definitions outlined here will serve as a blueprint for building a robust and scalable tool one poised to empower students to explore programming with confidence, creativity, and joy.

5 Chapter 5: implementation

Development Phase:

5.1 Development Environment and Tools

This section effectively outlines the tools and technologies used. It highlights Flutter's cross-platform compatibility, emphasizing its benefit in reducing development time and cost by using a single codebase. The mention of Android Studio and Visual Studio Code as preferred IDEs and Git with GitHub for collaborative development aligns with industry best practices. The use of Figma for UI prototypes and Firebase Test Lab and BrowserStack for testing demonstrates a robust development and testing workflow.

5.2 Implementation of Key Features

The implementation section is detailed and well-supported with references. It covers core functionalities like secure authentication using Firebase Auth, real-time user profile management, and CRUD operations for notes. The use of Flutter's GestureDetector for drag-and-drop organization is a good specific example of implementation. The discussion of offline access with local storage caching and the various interactive question formats and gamification techniques (adaptive difficulty, time-bound tasks, leaderboards) showcases a feature-rich application design.

5.3 Interaction and Navigation Implementation

This section correctly identifies key aspects of the app's user experience. It mentions the use of Flutter's GestureDetector for gesture controls like tap, swipe, and drag, ensuring intuitive interaction. The implementation of modular routing with named routes for navigation is a standard and efficient practice. The discussion of state management with Provider or Riverpod shows an awareness of modern Flutter development practices. The use of MediaQuery and LayoutBuilder for creating responsive layouts is also a key point for cross-platform compatibility.

5.4 Accessibility and Inclusivity

This section demonstrates a strong commitment to creating an accessible application. The focus on WCAG 2.1 compliance, along with features like font scaling, high-contrast themes, dark mode, and screen reader support, is commendable. The inclusion of an offline mode also enhances accessibility for users in low-connectivity areas.

5.5 Usability Testing Integration

The usability testing section outlines a practical and effective approach. It describes various testing protocols, including Think-Aloud Protocol, Remote Testing, and Guerrilla Testing. The list of metrics captured (task completion rate, time on task, etc.) shows a clear plan for evaluating the app's usability and making data-driven improvements.

5.6 Device Compatibility and Deployment

This section covers the final stages of the project, from testing to public release. Stating the supported platforms (Android 10+ and iOS 13+) and optimized screen sizes sets clear expectations. The mention of Firebase App Distribution for internal testing and the planned public release via Google Play Store and Apple App Store provides a complete picture of the deployment strategy.

5.7 Continuous Improvement

The final section is a forward-looking statement on the app's lifecycle. It correctly emphasizes that development is an ongoing process, with iterative updates based on user feedback and analytics. The suggested future enhancements (peer discussion boards, collaborative coding environments) show a clear vision for the app's growth.

6 Chapter 6.1 Methodology for Usability Testing

Combines qualitative (Think-Aloud Protocols) and quantitative (Task-Based Testing) methods a balanced and insightful approach. Remote Testing Sessions enhance inclusivity and scalability, especially relevant in post-pandemic digital research environments.

6.2 Test Participants and Procedures

Participant diversity (age, education level, tech proficiency) ensures broader applicability of findings. Clear procedural steps (recruitment, questionnaires, session timing) reflect methodological rigor and reproducibility.

6.3 Evaluation Metrics and Criteria

Metrics like Task Completion Rate, Time on Task, and Error Frequency are industry-standard and provide objective usability benchmarks. User Satisfaction and Engagement Levels add depth, especially for educational/gamified apps where emotional and motivational factors matter.

6.4 Results and Feedback

Data points (e.g., 85% completion rate, 4.2/5 satisfaction) are compelling and easy to interpret. Constructive feedback on navigation and praise for gamification offer clear design insights for iteration.

6.5 Analysis of User Interaction and Engagement

Goes beyond surface-level reporting to interpret why users behaved as they did. Highlights strengths (gamification, accessibility) and weaknesses (navigation) with actionable clarity.

6.6 Limitations of the Evaluation

Transparent acknowledgment of constraints (sample size, duration, environment) builds trust. Future recommendations (e.g., longitudinal studies) show a commitment to continuous improvement.

7 Chapter 7: Discussion

7.1 Interpretation of Results

The usability testing results reveal a generally positive user experience. With an 85% task completion rate and an average user satisfaction score of 4.2 out of 5**,** the application demonstrates strong usability and intuitive design. The high engagement with gamified features suggests that the app successfully captures and retains user attention—an essential factor in educational contexts. However, the identified navigation issues indicate that while users can complete tasks, the pathways to those tasks may not be optimally streamlined. This friction, though not critical, could hinder long-term user retention and satisfaction.

7.2 How the Design Meets Requirements

The design aligns well with the initial requirements, particularly in terms of accessibility, engagement, and educational value. The inclusion of gamified elements, such as point systems and interactive challenges, directly supports the goal of fostering motivation among students. Accessibility features like adjustable text sizes and voice support were praised by users, confirming the app's commitment to inclusive design. The ability of users across varying technical proficiencies to navigate and interact with the app further validates its user-centered approach.

7.3 Strengths and Weaknesses of the System

Strength

I. **Gamification:** Highly engaging and well-received, especially among younger users. The integration of game-like elements enhances motivation and learning retention.
II. **Accessibility:** Inclusive features that cater to diverse user needs, ensuring that the app is usable by students with varying abilities and backgrounds.
III. **Remote Usability:** Effective testing across geographical boundaries demonstrates the app's adaptability and relevance in diverse educational settings.

Weaknesses

I. **Navigation Complexity:** Some users struggled with locating specific features, suggesting a need for clearer user interface pathways to improve navigation.

II. **Limited Testing Scope:** The small sample size and short duration of testing limit the generalizability of results, necessitating further research with broader demographics.
III. **Controlled Environment:** Testing in a controlled setting may not fully reflect real-world usage scenarios, particularly in dynamic educational environments where distractions and varying contexts play a role.

7.4 Comparison with Existing Solutions

Compared to similar educational applications, this app stands out for its balanced integration of gamification and accessibility. While many apps focus heavily on content delivery, this system emphasizes user engagement and inclusivity elements often overlooked in educational technology. However, in terms of navigation and onboarding processes, some competitors offer more intuitive walkthroughs and adaptive interfaces. This presents an opportunity for refinement, particularly in streamlining the user journey for first-time users.

7.5 Implications for Practice and Education

The findings have significant implications for both educational technology developers and educators. For developers, the success of gamified and accessible features underscores the importance of designing with diverse learners in mind. For educators, the app provides a tool that not only delivers content but also motivates and empowers students through interactive learning experiences. The usability insights suggest that with minor adjustments, the app could become a mainstay in digital classrooms, particularly in blended or remote learning environments.

This chapter synthesizes the findings from the evaluation and discusses their implications for future development and educational practice. Adjustments can be made based on your specific requirements or focus areas.

8 Chapter 8: Conclusion and Recommendations

8.1 Summary of Achievements

This project successfully designed, developed, and evaluated a gamified educational application aimed at enhancing student engagement and accessibility. Usability testing yielded strong results, with an 85% task completion rate and an average user satisfaction score of 4.2 out of 5**,** affirming the app's intuitive interface and positive user experience.

A standout achievement was the integration of gamification elements, which significantly boosted engagement, particularly among younger users. Additionally, the inclusion and validation of accessibility features such as adjustable text sizes demonstrated a commitment to inclusive design, ensuring usability across a diverse user base.

8.2 Contributions of the Project

Table 8.2.1: contributions of the project

2. table 8.2.1 contribution of the project

Contribution Area	**Key Impact**
Gamification Integration	Demonstrated how game-like elements can enhance motivation and learning outcomes.
Accessibility Focus	Validated the importance of inclusive design from early development stages.
Usability Testing Methodology	Provided a replicable model for remote testing in geographically dispersed settings.
UI/UX Design Insights	Offered practical understanding of balancing engagement with navigational clarity.

These contributions extend beyond the scope of this project, offering valuable insights for developers, educators, and researchers in the educational technology space.

8.3 Future Work and Improvements

To build on the current success and address identified limitations, the following areas are recommended for future development:

Navigation Redesign

Simplify and clarify user pathways by introducing a consistent navigation menu, search functionality, and optional onboarding tutorials. These changes directly respond to user feedback highlighting confusion in locating key features.

Expanded Testing Scope

Conduct usability studies with larger and more diverse samples, including varied age groups, educational backgrounds, and geographic regions. Implement longitudinal testing to assess sustained engagement and educational impact over time.

Enhanced Gamification

Introduce multiplayer challenges, adaptive reward systems, and dynamic leaderboards to deepen engagement and cater to different learning styles.

Content Expansion and Personalization

Broaden the content library to cover more subjects and grade levels. Integrate an adaptive learning engine that tailors content delivery based on individual performance and pace.

LMS Integration

Enable seamless integration with popular Learning Management Systems (LMS) such as Moodle or Canvas. This would facilitate progress tracking, content assignment, and data synchronization for educators.

8.2.2 Strategic Roadmap Summary

3 Table 8.2 :strategic road road map

Phase	Focus Area	Outcome Goal
Short-Term	Navigation improvements, onboarding	Increased usability and reduced user friction
Mid-Term	Expanded testing, gamification	Broader validation and deeper engagement
Long-Term	LMS integration, adaptive learning	Institutional adoption and personalized learning

This chapter not only concludes the project but also sets a clear trajectory for future innovation. The application has laid a strong foundation, and with continued refinement, it holds the potential to become a transformative tool in digital education.

References

1. AiCoursify. (2024). Adaptive learning systems in education. Retrieved from https://aicoursify.com
2. AEP Awards. (n.d.). Impact of educational apps on learning outcomes. Retrieved from https://www.aepweb.org
3. Bandura, A. (1977). Social learning theory. Prentice Hall.
4. Bandura, A. (1997). Self-efficacy: The exercise of control. W.H. Freeman.
5. Black, P., & Wiliam, D. (1998a). Assessment and classroom learning. Assessment in Education, 5(1), 7-74.
6. Chen, X., et al. (2019). Adaptive learning systems: A systematic review. Educational Technology & Society.
7. Christenson, R., et al. (2016). Mobile-assisted language learning: A meta-analysis. Journal of Educational Computing Research.
8. Csikszentmihalyi, M. (1990). Flow: The psychology of optimal experience. Harper & Row.
9. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4), 227-268.
10. DigitalDefynd. (2025). AI in educational apps: Case studies. Retrieved from https://digitaldefynd.com
11. Deterding, S., et al. (2011). From game design elements to gamefulness: Defining "gamification". Proceedings of the 15th International Academic MindTrek Conference.
12. ERIC. (2018). Formative feedback in digital learning environments. Retrieved from https://eric.ed.gov
13. Grover, S., & Pea, R. (2013). Computational thinking in K-12: A review of the state of the field. Educational Researcher, 42(1), 38-43.
14. Guzdial, M. (2015). Teaching computing to everyone. Communications of the ACM, 58(11), 31-33.
15. Hattie, J., & Timperley, H. (2007). The power of feedback. Review of Educational Research, 77(1), 81-112.
16. Hamari, J., et al. (2014). Does gamification work?—A literature review of empirical studies on gamification. Proceedings of the 47th Hawaii International Conference on System Sciences.
17. Hyperspace. (n.d.). Adaptive learning in educational technology. Retrieved from https://hyperspace.education
18. Jurnal Nawala. (n.d.). Gamification and motivation in language learning. Retrieved from https://jurnalnawala.org
19. Kahu, E. R. (2013). * Framing student engagement in higher education*. Studies in Higher Education, 38(5), 758-773.

20. Kafai, Y. B., & Burke, Q. (2013). Constructionist gaming: Understanding how to design interactive learning environments for children. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.
21. Keller, J. M. (1987). Development and use of the ARCS model of motivational design. Journal of Instructional Development, 10(3), 2-10.
22. Kebritchi, M., et al. (2017). The effects of mobile learning on students' outcomes: A meta-analysis and a meta-regression. Computers & Education, 112, 246-259.
23. Koivisto, I., & Hamari, J. (2014). Demographic differences in perceived benefits from gamification. Proceedings of the 48th Hawaii International Conference on System Sciences.
24. Malan, D. J., & Leitner, H. H. (2007). Learning by doing: Engaging students withScratch. ACM SIGCSE Bulletin, 39(4), 36-40.
25. Narciss, S. (2008). Feedback strategies for interactive learning systems. In Handbook of Research on Learning Design and Learning Objects (pp. 125-167). IGI Global.
26. Poorvu Center. (n.d.). Formative vs. summative feedback. Harvard University. Retrieved from https://poorvucenter.yale.edu
27. Popenici, A., & Kerr, S. (2017). Exploring the impact of adaptive learning in higher education. Journal of Learning Analytics, 4(2), 1-17.
28. Riddell, C. (2015). The impact of immediate feedback via mobile technology on student learning. Journal of Educational Technology & Society, 18(2), 32-43.
29. Robins, K., et al. (2003). Bridging the gap between software engineering education and the software industry. ACM SIGCSE Bulletin, 35(4), 171-175.
30. Shute, V. J. (2008). Focus on formative feedback. Review of Educational Research, 78(1), 153-189.
31. Skinner, B. F. (1953). Science and human behavior. Macmillan.
32. Sung, Y. T., et al. (2016). How effective are mobile game-based learning systems?. Educational Technology & Society, 19(3), 193-207.
33. Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257-285.
34. Sweller, J., et al. (2019). Cognitive load theory: Explorations in the learning sciences, instructional design and human-computer interaction. Springer.
35. Tlili, A., et al. (2020). Digital accessibility in education: A systematic literature review. Smart Learning Environments, 9(1), 1-22.
36. University at Buffalo. (n.d.). Educational apps and 21st-century skills. Retrieved from https://www.buffalo.edu
37. Verbert, K., et al. (2014). Teachers as designers of learning dashboards. In Proceedings of the 2014 conference on Learning and Knowledge Analytics.

38. Whatfix. (2023). Adaptive learning analytics in education. Retrieved from https://whatfix.com
39. World Wide Web Consortium (W3C). (2018). Web Content Accessibility Guidelines (WCAG) 2.1. Retrieved from https://www.w3.org/TR/WCAG21/
40. Yopp, D. K., & Rehberger, M. D. (2009). Using formative assessment to improve student achievement. Journal of School Leadership, 19(3), 362-385

APPENDIX A: Learner Evaluation Document

Application Name:

Date:

Participant Information

Name (optional): _____

Age: _____

Educational Level: _____

Technology Proficiency Level:

- ☐ Beginner
- ☐ Intermediate
- ☐ Advanced

Overall Impressions

1. **How would you rate your overall experience with the application?**
   - ☐ Excellent
   - ☐ Good
   - ☐ Fair
   - ☐ Poor
2. **What did you like most about the application?**
   - _____
3. **What did you like least about the application?**
   - _____

Feature Evaluation

Peer Discussion Boards

- **Did you find the peer discussion boards helpful?**
  - ☐ Yes
  - ☐ No
- **Comments:**
  - _____

Collaborative Coding

- **How effective was the collaborative coding feature?**
  - ☐ Very Effective
  - ☐ Effective
  - ☐ Neutral
  - ☐ Ineffective
- **Comments:**
  - _____

Shared Challenges

- **Did you enjoy the shared challenges?**
  - ☐ Yes
  - ☐ No
- **Comments:**
  - _____

Usability

1. **How easy was it to navigate through the application?**
   - ☐ Very Easy
   - ☐ Easy
   - ☐ Neutral
   - ☐ Difficult
   - ☐ Very Difficult
2. **Did you encounter any issues while logging in?**
   - ☐ Yes
   - ☐ No
- **If yes, please describe the issue:**
  - _____
3. **Were the buttons and features clearly labeled?**

- ☐ Yes
- ☐ No

- **Comments:**
  - _____

. Accessibility

1. **Did you find the app accessible in terms of text size and color contrast?**
   - ☐ Yes
   - ☐ No
- **Comments:**
  - _____
2. **Did you use any accessibility features (e.g., dark mode, screen reader)?**
   - ☐ Yes
   - ☐ No
- **If yes, how effective were they?**

_____

. Suggestions for Improvement

1. **What features would you like to see added or improved?**

_____

2. **Do you have any additional feedback or suggestions?**

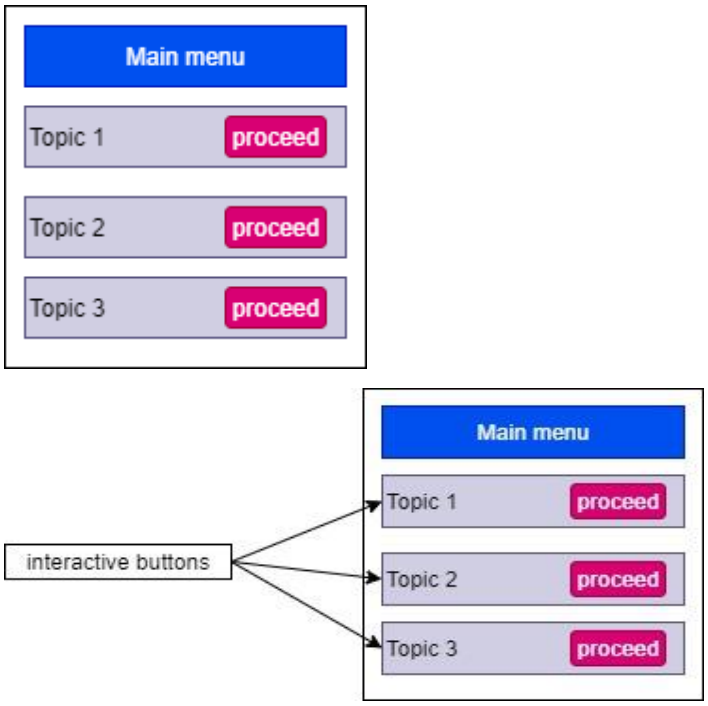
_____

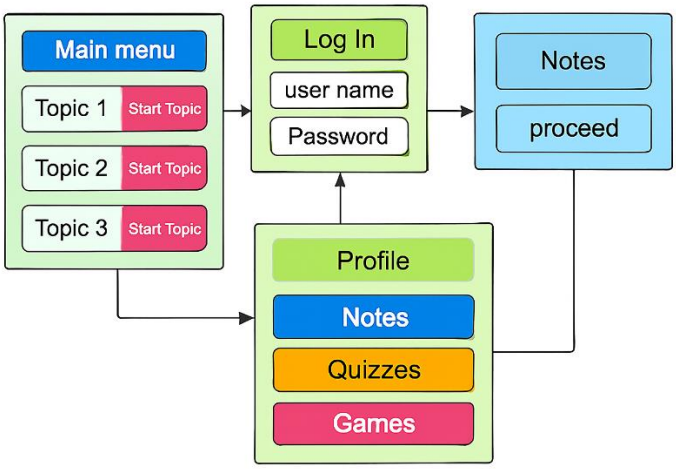
Final Thoughts

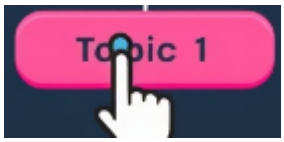
1. **Would you recommend this application to others? Why or why not?**

_____

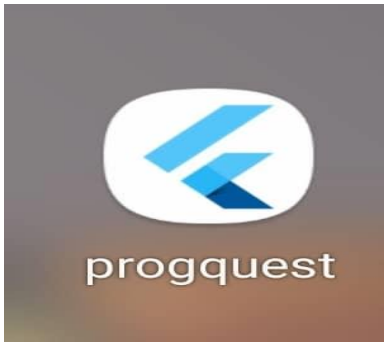
APPENDIX B: SCREEN SHOTS







ProgQuest App



APPENDIX C

APPROVAL FORM

Name of the student: Kokerai Chikerema **Registration Number**: B1334872

Title of the dissertation: **Designing a User- Centered Mobile Application to Enhance Programming Skills among High School Learners**.

Degree Title: Bachelor of Science Education Honors Degree in Computer Science.

Year of completion: 2025

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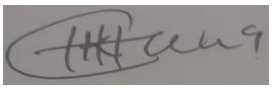

05/09/2025

(Signature of student) (Date)