# PROGRAMMING LEARNING APP FOR KIDS: PROJECT BASED PROGRAMMING EDUCATION

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## 2. Abstract

Sri Lanka's economy is facing significant challenges due to the escalating USD crisis, which has adversely impacted key sectors such as tourism, tea exports, and garments. While the IT sector has historically been a stabilizing force, its potential remains untapped. The increasing trend of outsourcing to South Asian countries, particularly India, has highlighted a critical knowledge gap in programming among Sri Lankan youth. This disparity is hindering the country's ability to compete effectively in the global IT market and capitalize on the outsourcing boom.

To bridge the programming knowledge gap and position Sri Lanka as a competitive IT hub, this research proposes a novel mobile application. The app is designed to introduce coding concepts to children through an engaging and interactive story-based learning approach. By making programming accessible and enjoyable from a young age, the app aims to cultivate a strong foundation in IT skills. Additionally, the app will incorporate a customized child assistance system to provide tailored support and guidance, ensuring that learners progress at their own pace.

The successful implementation of this mobile application is expected to have a profound impact on Sri Lanka's IT landscape. By nurturing a generation of proficient programmers, the country can significantly enhance its capacity to participate in the global IT market. This, in turn, will contribute to economic growth, job creation, and foreign exchange earnings. Moreover, the app has the potential to serve as a model for other developing countries facing similar challenges, promoting knowledge sharing and collaboration on a global scale.

Key Words: Machine Learning, Mobile Solution , e-learning

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## 7. List of Abbreviations

| Abbreviations | Description |
|---|---|
| NLP | Natural Language Processing |
| ML | Machine Learning |
| ICT | Information and Communication Technology |
| IT | Information Technology |
| GDP | Gross Domestic Product |
| RAG | Retrieval Augmented Generation |
| QA | Question & Answer |
| GPT | Generative Pre-trained Transformer |
| AI | Artificial Intelligence |

# 8. Introduction

## 8.1. Background Literature

Sri Lanka's tourism industry stands as a cornerstone of its economy, contributing significantly to GDP (12.5%). It generates substantial foreign exchange, supporting a diverse range of businesses and livelihoods across the country. Tourism serves as a catalyst for infrastructure development, leading to improved transportation, accommodations, and public services that benefit both visitors and locals. The industry plays a crucial role in showcasing Sri Lanka's rich cultural heritage and natural beauty, fostering a sense of national pride and encouraging preservation efforts. Furthermore, tourism has the potential to drive sustainable development by promoting eco-friendly practices and supporting local communities. While the COVID-19 pandemic dealt a severe blow to the sector, its inherent resilience and ability to rebound make it a key driver of economic recovery and future growth.

The COVID-19 pandemic inflicted a severe blow to Sri Lanka's tourism industry, resulting in far-reaching economic and social consequences. A dramatic decline of 30% in tourist arrivals during the first quarter of 2020 compared to the previous year marked the beginning of a catastrophic downturn. This plunge was primarily attributed to stringent travel restrictions, global lockdowns, and widespread health concerns. The economic repercussions were equally devastating. The industry, a significant foreign exchange earner, suffered projected revenue losses of between USD 107 million to USD 319 million. This financial crisis triggered a domino effect, impacting businesses across the tourism value chain. Hotels, travel agencies, and transportation services faced unprecedented challenges, leading to widespread job losses and increased unemployment.

Beyond the immediate impact on the tourism sector, the crisis reverberated through the broader economy. Interconnected industries such as hospitality, agriculture, and retail experienced a decline in business due to the reduced tourist activity. Moreover, the slowdown in tourism hampered infrastructure development and foreign direct investment, hindering the industry's long-term growth prospects. The pandemic also

compelled a shift in consumer behavior, with travelers prioritizing health and safety. To recover, the tourism industry must adapt to these new preferences and implement strategies to rebuild trust. The crisis has underscored the urgent need for comprehensive recovery plans, including financial relief for businesses, job retention initiatives, and innovative approaches to utilizing tourism resources [1].

The COVID-19 pandemic severely impacted Sri Lanka's tea industry. Global supply chain disruptions, coupled with a sharp decline in global tea demand, caused significant challenges for the sector. Export volumes plummeted due to these factors, forcing a shift in focus towards new markets. The crisis accelerated the adoption of digital tea auctions, a long-overdue transformation that holds potential for future growth. However, small and medium-sized enterprises within the industry were particularly vulnerable to the pandemic's effects, highlighting the need for targeted support. Overall, the pandemic exposed the tea sector's vulnerabilities and necessitated a strategic response to rebuild and strengthen its position in the global market [2].

Sri Lanka's garment industry is a vital economic pillar, serving as a major source of employment and foreign exchange earnings. The sector employs a substantial portion of the workforce, particularly women, contributing significantly to the nation's GDP. As a key export-oriented industry, garments have been a driving force behind Sri Lanka's economic growth. The industry's interconnectedness with other sectors underscores its importance within the broader economy. While the COVID-19 pandemic posed significant challenges, the sector's resilience has been evident in its ability to adapt to changing circumstances, highlighting its potential for future growth and development. The Sri Lankan garment industry, a cornerstone of the nation's economy, suffered a catastrophic downturn due to the COVID-19 pandemic. The industry, which had been a significant source of employment and foreign exchange, experienced a sharp decline in export earnings. With global demand plummeting due to lockdowns and economic contractions in major markets, garment manufacturers faced a perfect storm of challenges. A precipitous drop in export orders resulted in mass job losses, casting a long shadow over the livelihoods of hundreds of thousands of workers and their families.

The pandemic-induced disruptions to global supply chains exacerbated the crisis, hindering the procurement of essential raw materials and the timely delivery of finished products. Consequently, production schedules were thrown into disarray, and operational costs surged. Small and medium-sized enterprises, which form the backbone of the garment sector, were particularly vulnerable to the pandemic's impact. Facing a dramatic reduction in sales and mounting financial pressures, many struggled to stay afloat. The overall economic contraction in Sri Lanka, exacerbated by the decline in the garment industry, had far-reaching consequences, impacting the nation's GDP growth and overall economic stability. The pandemic exposed the fragility of the garment industry's reliance on global markets and highlighted the urgent need for diversification and resilience-building strategies. As Sri Lanka navigates the path to recovery, rebuilding the garment sector will be crucial for restoring economic growth and creating employment opportunities [3].

Sri Lanka's economy, heavily reliant on tourism, tea exports, and garment manufacturing, has been severely impacted by the COVID-19 pandemic. The abrupt decline in these sectors due to global travel restrictions, supply chain disruptions, and reduced demand has led to a substantial loss of foreign exchange earnings. Consequently, the country has experienced significant USD inflation as its economic stability has been compromised. The economic crisis precipitated by the collapse of Sri Lanka's key revenue streams—tourism, tea exports, and garment manufacturing—has had a devastating impact on the lives of ordinary citizens. The sharp decline in these sectors has triggered a cascade of challenges, including widespread job losses, income reduction, and a surge in poverty rates. This economic hardship has disproportionately affected vulnerable populations, such as daily wage earners and low-income families.

The shift to online education, necessitated by the pandemic, has exacerbated existing educational disparities. While intended to mitigate the disruption to learning, it has highlighted the digital divide, with many students lacking adequate access to technology and internet connectivity. Beyond economic hardship, the crisis has also

had profound social consequences. The increased stress and isolation brought about by lockdowns and restrictions have contributed to a rise in domestic violence and mental health issues. Moreover, the disruption of social networks and community support systems has eroded the overall well-being of the population. In essence, the economic downturn has created a complex web of challenges that have eroded the quality of life for Sri Lankans across all segments of society [4].

Information and Communication Technology (ICT) has emerged as a pivotal driver of economic growth and development in Sri Lanka. By fostering the evolution of a robust IT industry, the nation has the potential to diversify its economic base, reducing overreliance on the garment sector. This sectoral shift offers a promising avenue for job creation, particularly for graduates confronting unemployment challenges. Furthermore, the integration of ICT into commercial and industrial operations is poised to enhance Sri Lanka's global competitiveness through the expansion of e-commerce activities. Beyond economic imperatives, ICT is instrumental in optimizinggovernance and public administration, facilitating the timely dissemination of essentialinformation to underpin economic progress.

Information and Communication Technology (ICT) has emerged as a pivotal force driving Sri Lanka's economic development. Substantial investments in telecommunications infrastructure have laid the groundwork for a digitally connected nation. This enhanced connectivity has facilitated efficient business operations, improved access to global markets, and accelerated the adoption of digital services. E-governance has been a cornerstone of Sri Lanka's digital transformation. By streamlining public administration, reducing bureaucratic hurdles, and enhancing service delivery, the government has created a more conducive business environment. This, in turn, has attracted domestic and foreign investments, stimulating economic growth.

ICT has been instrumental in developing human capital. Online education platforms, vocational training programs, and digital literacy initiatives have expanded access to knowledge and skills, equipping the workforce for the demands of the digital age. The

IT sector itself has emerged as a significant job creator, contributing to youth employment and reducing unemployment rates. Sri Lanka has witnessed a burgeoning startup ecosystem, fueled by ICT. The availability of digital tools and platforms has empowered entrepreneurs to develop innovative solutions to local challenges. This entrepreneurial spirit has driven economic growth and created new job opportunities. By leveraging ICT, Sri Lanka has integrated more effectively into the global economy. Businesses can now access international markets, expand their customer base, and increase exports. Moreover, ICT has facilitated foreign direct investment by providing potential investors with real-time information about the business environment [5].

In conclusion, ICT has been a catalyst for Sri Lanka's economic transformation. Its impact is evident in various sectors, from agriculture to healthcare. Continued investment in ICT infrastructure and human capital development will be crucial for sustaining this momentum and achieving the nation's economic goals. During this pandemic period the outsourcing has been emerged rapidly. Outsourcing refers to the strategic delegation of specific organizational functions or processes to externalservice providers. By contracting with specialized third-party entities, organizations can optimize resource allocation, enhance operational efficiency, and focus on core competencies. This practice enables firms to leverage external expertise, reduce costs, and mitigate risks associated with non-core activities.

Commonly outsourced functions encompass a broad spectrum, including but not limited to information technology, human resources, customer service, finance and accounting, marketing and sales, supply chain management, and legal services. The COVID-19 pandemic has accelerated the adoption of outsourcing as a strategic business decision. Organizations across industries have recognized the numerous benefits it offers in navigating the challenges posed by the crisis [6].

By outsourcing non-core functions, businesses can significantly reduce operational costs. Eliminating expenses related to recruitment, training, and office infrastructure has been crucial for maintaining profitability during these economically challenging times. Moreover, outsourcing provides access to specialized skills and expertise that

may be scarce in-house, particularly in areas such as technology and remote operations. The pandemic has underscored the importance of operational flexibility. Outsourcing enables organizations to quickly scale up or down their workforce in response to changing market conditions and customer demands. This agility is essential for surviving and thriving in an unpredictable business environment [6].

Finally, outsourcing can accelerate digital transformation and innovation. By partnering with external experts, businesses can gain access to new ideas, processes, and technologies, enhancing their ability to adapt to the evolving market landscape.
Outsourcing, the strategic delegation of organizational functions to external providers, has evolved into a prevalent business model across industries. This practice has been particularly pronounced within the Information and Communication Technology(ICT) sector, There are some advantages in this as well, Outsourcing ICT services has emerged as a strategic imperative for organizations seeking to optimize operations, reduce costs, and enhance competitiveness. By leveraging external expertise, companies can streamline their ICT functions and focus on core competencies [7].

One of the primary benefits of outsourcing is cost reduction. By eliminating the overhead associated with maintaining an in-house ICT department and capitalizing on lower labor costs in certain regions, organizations can achieve significant cost savings. Moreover, outsourcing provides access to a specialized talent pool, ensuring that businesses have the necessary expertise to address complex ICT challenges and stay ahead of technological advancements [7].

Outsourcing offers unparalleled flexibility and scalability. Companies can easilyadjust their ICT resources to align with fluctuating business demands, without the burden of hiring and training additional staff. This agility is crucial in today's dynamicbusiness environment. By partnering with experienced ICT service providers, organizations can mitigate risks associated with data security, compliance, and system failures. Outsourcing providers often have robust security measures and disaster recovery plans in place, safeguarding sensitive information and ensuring business continuity [7].

While the potential impact on employment is a concern, many companies have successfully managed this transition through redeployment and upskilling initiatives. The overall trend suggests that outsourcing creates new opportunities in the ICT sector, stimulating job growth in areas such as project management, ICT consulting, and service delivery. Outsourcing has emerged as a powerful driver of economic growth in South Asia. Countries like India have become global leaders in ICT services outsourcing, generating substantial revenue and creating millions of jobs. This surge in the ICT sector has contributed significantly to overall economic development and improved living standards. The outsourcing industry has fostered a skilled workforce in the region. Educational institutions have aligned their curricula with the demands of the ICT sector, producing graduates with the necessary expertise. This human capital development has been instrumental in enhancing the region's competitiveness on the global stage [8].

Moreover, outsourcing has attracted significant foreign direct investment (FDI) to South Asia. The influx of capital has fueled infrastructure development and supported the growth of the ICT sector. This symbiotic relationship between outsourcing and FDI has accelerated economic progress. The transfer of technology and knowledge from developed countries to South Asian nations through outsourcing has been a key factor in driving innovation. Local companies have been able to enhance their capabilities and compete effectively in the global market [8].

Even though outsourcing has been increased in South Asian countries drastically and while outsourcing has emerged as a strategic imperative for many organizations, it is not without its challenges. A primary concern is job security, as the transfer of functions to external providers can lead to job displacement within the outsourcing organization. Moreover, outsourcing often raises questions about wage disparities, as labor costs can vary significantly between countries. The potential for exploitation of workers, particularly in developing economies, is a critical ethical issue. The distribution of benefits from outsourcing has also been uneven across regions. Certain South Asian countries have experienced substantial economic growth and job creation

through outsourcing, while others have lagged behind. This has contributed to intra-regional disparities in development, with some countries experiencing rapid industrialization and technological advancement, while others grapple with persistent poverty and unemployment [8].

The global outsourcing landscape has witnessed a significant surge, with South Asian nations emerging as prominent players. India, in particular, has solidified its position as a global leader in IT services outsourcing, capturing a substantial portion of the market share previously dominated by Western economies. This dominance can be attributed to several factors, including a large pool of English-proficient, technically skilled labor, a favorable cost structure, and a conducive business environment.
In contrast, while countries like Pakistan and Bangladesh have also made inroads into the outsourcing industry, their market share remains comparatively smaller. Sri Lanka, despite possessing a skilled workforce, has faced challenges in establishing a significant foothold in the global outsourcing arena.

A key factor contributing to the disparity in outsourcing penetration across South Asian nations is the knowledge gap in technology and programming. India hasinvested heavily in education and skill development, producing a large talent pool proficient in emerging technologies. This emphasis on STEM education has equippedIndian youth with the requisite skills to meet the demands of the global IT industry.
Sri Lanka, while making strides in education, has lagged behind in producing graduates with the specialized skills sought after by multinational corporations. This skills gap, coupled with factors such as infrastructure limitations and policy challenges, has hindered the country's ability to compete effectively in the global outsourcing market.

To bridge this divide and enhance Sri Lanka's position in the outsourcing industry, targeted investments in education, skill development, and infrastructure areimperative. By fostering a robust ICT ecosystem and creating a conducive business environment, Sri Lanka can attract a larger share of the global outsourcing market.

This research was initiated in response to a perceived gap in programming education among young children. The primary objective was to identify strategies to introduce fundamental programming concepts to a younger demographic. Given the ubiquitous nature of smartphones among children, the research culminated in the proposition of a mobile application as a potential solution.

### 8.2. Research Gap

The research gap in personalized programming education for Tamil-speaking students presents a unique opportunity to address long-standing educational inequalities by leveraging advanced AI technologies and tailoring them to underrepresented linguistic communities. While significant strides have been made in personalized learning systems for mainstream languages, such as English and Chinese, the educational needs of linguistic minorities, particularly in regions like Sri Lanka, have often been overlooked. Existing studies have demonstrated the effectiveness of personalized learning in improving student outcomes across various fields, including programming. For instance, research by Brusilovsky and Millán [9] highlights the power of adaptive hypermedia and personalized content in enhancing student engagement and retention. However, there is a clear research gap when it comes to applying these innovations to non-English-speaking students. Tamil-speaking learners, especially in rural or underserved areas, face additional challenges related to language barriers and limited access to culturally relevant learning materials.

The introduction of AI-driven tools such as LLAMA2 with RAG in the "CodeSafari" platform begins to bridge this gap, yet the scope of research remains narrow. Studies by Luckin et al. [10] and Romero & Ventura [11] have highlighted the potential of digital education and data mining to create more inclusive learning environments. However, most of these studies fail to focus on the needs of linguistic minorities, particularly in programming education. This gap is especially concerning given the increasing demand for IT skills in the global economy. Tamil-speaking students, who are already at a disadvantage due to the lack of accessible educational content, risk falling further behind if educational technologies are not adapted to their linguistic and cultural needs. Expanding research in this area would not only address a significant gap in the literature but could also open up new opportunities for these students in the

rapidly growing tech sector.

Furthermore, the current body of research on personalized learning systems, while extensive, has primarily focused on short-term outcomes such as immediate engagement and test scores. Long-term studies are sorely lacking, particularly in the context of minority language groups. Research like that conducted by Liao et al. [12] and Roediger & Butler [13] focuses on short-term learning outcomes through predictive models and retrieval practice but does not extend into long-term impacts on student progression, particularly in Tamil-speaking contexts. A key area for future research is the exploration of how personalized programming platforms, such as "CodeSafari," impact student outcomes over an extended period. Do these students continue to engage with IT education? Do they pursue careers in technology fields at a higher rate than those who do not have access to such platforms? Without longitudinal data, it is difficult to assess the true effectiveness of personalized learning systems, particularly in non-English-speaking contexts where the educational infrastructure may be lacking.

Moreover, while tools like LLAMA2 with RAG have been shown to be effective in generating personalized educational content, there is limited research on their application in programming education for Tamil-speaking students. Current AI models have primarily been tested in English-speaking environments, and it is unclear whether their success can be replicated in a Tamil context. Research by Mayer [14] on multimedia learning suggests that students perform better when educational content is culturally relevant and delivered in their native language. However, much of the existing literature fails to address how these AI models can be adapted for use in minority languages. The "CodeSafari" platform's use of real-time Tamil translation via the OpenAI API is a step in the right direction, but more research is needed to determine how effectively these translations convey complex programming concepts.

*Table 1. COMPASION OUR SYSTEM WITH EXISTING SYSTEMS*

| Research Papers | Provide a Project System | Using AI | Using Native language |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Learning Platform [3] | | ✓ | |
| Project Based Learning Platform | ✓ | ✓ | |
| Color App [5] | | | |
| Learning Math through Mobile Game [6] | | ✓ | |
| Our Solution | ✓ | ✓ | ✓ |
| Narrative-based learning platform [2] | ✓ | | |
| AI based Kids Interactive | ✓ | ✓ | |

Additionally, there is a significant gap in the research surrounding the socioeconomic factors that influence the adoption and effectiveness of AI-driven educational tools in low-resource environments. Table (1) reflects it. While Romero & Ventura [11] discuss the potential of educational data mining to optimize learning, they do not account for the digital divide that exists in countries like Sri Lanka. Tamil-speaking students in rural areas may have limited access to the internet and devices, which can hinder their ability to engage with platforms like "CodeSafari." Future research should focus on how to adapt personalized learning systems to function in offline or low-bandwidth environments. Additionally, studies should investigate how to make these systems more accessible to students with limited digital literacy, ensuring that the benefits of AI-driven education are not restricted to those in urban, well-connected areas.

The gap in project-based learning (PBL) within the context of personalized programming education for Tamil-speaking students is another area ripe for exploration. While studies like those by Blumenfeld et al. [15] have demonstrated the motivational benefits of PBL, there is little research on how AI can be integrated into these projects to provide real-time feedback and support. The "CodeSafari" platform's Project Generation Module begins to address this issue, but further research is needed to explore how AI can be used to assess and adapt programming projects as students progress. The integration of dynamic feedback systems could provide students with more meaningful learning experiences, helping them to apply theoretical knowledge to real-world problems. This is especially important in IT education, where practical application is key to mastering complex concepts.

Lastly, research on personalized feedback systems has predominantly focused on English-speaking students, leaving a significant gap in our understanding of how these systems perform in non-English contexts. Black & Wiliam's [16] research on formative assessment highlights the importance of personalized feedback in improving student outcomes, but their findings are based on English-speaking classrooms. There is a clear need for research that explores how feedback systems can be adapted for Tamil-speaking students, particularly in programming education where immediate, contextually relevant feedback is crucial for learning. Future studies could investigate how AI-driven feedback can be customized to meet the linguistic and cultural needs of Tamil-speaking learners, ensuring that they receive the guidance necessary to improve their programming skills.

In summary, while significant advancements have been made in the development of AI-driven personalized learning systems, there remains a substantial gap in the application of these technologies for Tamil-speaking students, particularly in programming education. The "CodeSafari" platform represents an important first step in addressing this gap, but further research is needed to refine these systems and ensure their effectiveness in diverse educational contexts. By focusing on long-term outcomes, socioeconomic factors, project-based learning, and personalized feedback systems, future research can help to create more inclusive, effective educational tools for Tamil-speaking students, ensuring that they are equipped with the skills necessary

to thrive in the global IT sector.

### 8.3. Research Problem

The author’s research is based on this, How to provide a basic knowledge of programming to kids ? ; Laying a strong foundation in programming at a young age can foster critical thinking, problem-solving, and creativity. To make programming accessible and engaging for children, it's essential to start with simple concepts and gradually introduce more complex ideas. Visual programming platforms, where children can drag and drop code blocks to create animations, games, or stories, offer an excellent starting point. Relating programming to real-world examples, such as how a robot follows instructions or how a video game works, can spark children's interest. Building on these foundational concepts, introduce sequencing, loops, and conditional statements through interactive activities and games. Encourage children to experiment and make mistakes, as these experiences contribute to the learning process. Emphasize the importance of problem-solving and breaking down complex tasks into smaller, manageable steps. As children gain confidence, introduce text-based programming languages, such as Python or JavaScript, and guide them through creating their own projects.

Creating a supportive learning environment is crucial. Encourage collaboration, provide constructive feedback, and celebrate successes. By making programming fun and rewarding, children are more likely to develop a sustained interest in the subject. Remember, the goal is not to produce mini programmers but to cultivate a mindset of curiosity, experimentation, and logical thinking. How to assist kids when they are having doubts? Providing effective support to children as they learn to program is crucial for fostering a positive and productive learning experience. When children encounter challenges, it's essential to create an environment where they feel comfortable asking questions and seeking help. One approach is to establish a clear communication channel, whether it's through online forums, dedicated support platforms, or one-on-one interactions with teachers or mentors. Encouraging children to articulate their doubts clearly can help them identify the specific areas where they need assistance.

Author’s research main objective is aims to address a critical disparity in engineering education between the home country and India. By identifying and analyzing the specific knowledge and skill gaps, the study seeks to develop strategies to elevate the engineering competency of local students to par with their Indian counterparts.
The core objective is to produce high-quality, industry-ready engineers capable of competing globally. This involves a comprehensive assessment of the current engineering curriculum, infrastructure, and faculty capabilities to pinpoint areas for improvement. Additionally, the research will examine successful engineering education models in India to identify best practices that can be adapted to the local context.

By understanding the root causes of the knowledge gap, the study will contribute to developing targeted interventions to enhance engineering education. This includes curriculum reform, faculty development, industry partnerships, and the creation of supportive learning environments. Ultimately, the goal is to produce engineers equipped with the necessary skills and knowledge to excel in the global engineering landscape. As answers for above research questions, Author can provide programming knowledge to kids is To effectively introduce programming concepts to children, a comprehensive understanding of how they interact with and learn from interactive platforms is essential. This exploratory analysis aims to delve into the core elements of interactive programming environments that facilitate learning.

Chiong and Shuler's research provides a foundational understanding of young children's interactions with mobile devices and applications. Despite the ubiquitous presence of smartphones and tablets in contemporary society, the study reveals a disparity between device ownership and actual usage among young children. While many households possess these devices, a significant proportion of children have limited exposure to them [14]. When children do engage with mobile technology, gaming often emerges as the primary activity. This finding aligns with broader cultural trends in which gaming has become a dominant form of digital entertainment. However, the study also highlights the adaptability of young children to technology. While some children required initial assistance, most demonstrated a surprising proficiency in navigating mobile devices, suggesting a natural affinity for technology [14].

Beyond entertainment, Chiong and Shuler's research offers glimpses into the educational potential of mobile apps. Specifically, the study identified "Martha Speaks" as a promising tool for enhancing vocabulary development among older children. The app's interactive features and engaging content appear to create a conducive environment for language acquisition. Similarly, "Super Why" demonstrated effectiveness in promoting literacy skills among younger children, indicating the potential of mobile apps to support early childhood education [14].

### 8.4. Research Objectives

The primary objective of this research is to address the knowledge gap in IT education for Tamil-speaking students in Sri Lanka through the development of a personalized learning platform. The project focuses on improving programming skills using advanced AI technologies such as LLAMA2 and Retrieval-Augmented Generation (RAG), creating quizzes and projects that adapt to the individual needs of students. The research is driven by the need to provide a comprehensive and scalable solution that caters to underrepresented linguistic communities, ensuring that Tamil-speaking students can compete in the global IT sector. Additionally, this project aims to contribute to the growing body of knowledge on personalized learning systems by exploring how such technologies can be effectively integrated into non-English educational environments, with a particular focus on underserved communities.

One of the key objectives of the research is to develop a system that tailors learning experiences to individual students based on their performance and progress. Personalized learning has been shown to significantly improve student engagement and retention, as highlighted by research in adaptive educational systems [17]. However, most of the existing personalized learning platforms have been developed for English-speaking audiences. The objective here is to adapt these technologies to the Tamil-speaking student population, ensuring that linguistic barriers do not hinder access to quality education. The platform’s integration of LLAMA2 and RAG allows for dynamic content generation that can adjust to each student's learning pace, providing real-time feedback and recommendations for further learning, which will be particularly beneficial for improving programming skills.

Another important research objective is to bridge the digital divide between urban and rural students in Sri Lanka. Research has consistently shown that students from rural areas often lack access to quality IT education, primarily due to language barriers and limited access to digital resources [18]. By incorporating real-time Tamil translation via the OpenAI API, this project seeks to make IT education more accessible to Tamil-speaking students, particularly those in rural areas. The platform's real-time translation feature ensures that students can fully engage with the educational content in their native language, thus breaking down linguistic barriers that often impede learning. This research aims to evaluate how real-time translation can improve comprehension and engagement, contributing to the broader field of multilingual education.

The research also aims to evaluate the effectiveness of machine learning models in assessing student progress and predicting future performance. Existing research on educational data mining has demonstrated the potential of machine learning models to predict student performance based on various factors, such as quiz scores, project completion rates, and time spent on tasks [19]. The system developed in this research will incorporate multiple machine learning models to provide a holistic evaluation of each student's IT knowledge. Specifically, the project will use a Regression Model to predict passing marks, a Classification Model for determining whether a student should skip levels, and a Recommendation System for personalized question suggestions. By analyzing these factors, the research seeks to optimize the learning process for Tamil-speaking students, providing targeted interventions that address individual learning gaps.

An additional objective of this research is to integrate project-based learning (PBL) into the personalized learning system. Project-based learning has been proven to enhance critical thinking and problem-solving skills, as it allows students to apply theoretical knowledge to real-world problems [20]. However, there is limited research on how PBL can be effectively personalized using AI technologies. The "CodeSafari" platform aims to address this by incorporating a Project Generation Module that dynamically creates projects based on the student's skill level and progress. This approach will help students develop practical IT skills while receiving personalized support from the system. Furthermore, the research aims to evaluate how project-based learning can be integrated with adaptive learning technologies to provide a

comprehensive educational experience that fosters both theoretical understanding and practical application.

Another key objective is to evaluate the long-term impact of personalized learning systems on student outcomes. While there is ample research on the short-term benefits of personalized learning, such as improved quiz scores and engagement, there is limited data on the long-term effectiveness of these systems [21]. This research will conduct a longitudinal study to assess how the personalized learning platform influences student outcomes over time. The goal is to determine whether the platform not only improves immediate learning outcomes but also fosters a sustained interest in IT education and helps students pursue careers in technology fields. The results of this study will contribute to the broader understanding of the long-term impact of personalized learning systems, particularly in non-English educational environments.

Moreover, this research seeks to explore the role of feedback in personalized learning. Research has shown that timely and personalized feedback is critical for improving student outcomes, particularly in programming education [22]. The "CodeSafari" platform incorporates an Answer Feedback Module that provides detailed feedback on quizzes and projects, allowing students to learn from their mistakes and improve their performance. This research aims to evaluate how personalized feedback, delivered in real time, influences student learning in a programming context. The findings of this study could provide valuable insights into how AI-driven feedback systems can be improved to enhance student outcomes in IT education.

Additionally, the research aims to contribute to the growing body of knowledge on multilingual education systems. While there has been considerable research on the development of multilingual educational platforms, much of it has focused on widely spoken languages like English, Spanish, and Mandarin [23]. There is a significant gap in the research on how to adapt educational technologies for minority languages like Tamil. By integrating real-time translation into the personalized learning system, this research aims to explore how multilingual education systems can be made more accessible and effective for students in underserved linguistic communities. The findings of this study could have broader implications for the development of educational technologies in other minority languages.

Finally, the research aims to develop a scalable educational platform that can be expanded to other regions and languages. While the initial focus is on Tamil-speaking students in Sri Lanka, the system is designed to be adaptable to other languages and regions. The research seeks to explore how the platform can be expanded to other minority languages, providing a scalable solution for personalized learning in underserved communities worldwide. The long-term goal is to create a flexible, AI-driven educational system that can be adapted to various linguistic and cultural contexts, providing personalized education to students in multiple regions.

In conclusion, the research objectives of this project are multifaceted, aiming not only to improve IT education for Tamil-speaking students but also to contribute to the broader fields of personalized learning, educational data mining, and multilingual education. By developing a personalized learning platform that integrates advanced AI technologies, real-time translation, and project-based learning, this research seeks to address key challenges in IT education for underrepresented linguistic communities. The findings of this research will have significant implications for the development of scalable, multilingual educational platforms that can provide personalized learning experiences to students worldwide.

# 9. Methodology

## 9.1. Methodology

The methodology for this research project focuses on implementing a personalized, adaptive learning platform aimed at enhancing IT education for Tamil-speaking students in Sri Lanka. This platform leverages cutting-edge AI technologies, such as LLAMA2 and Retrieval-Augmented Generation (RAG), to provide dynamic, contextually relevant quizzes and programming projects. The project adopts a mixed-methods approach, combining quantitative and qualitative data collection techniques to evaluate the effectiveness of the system. This section details the research design, data collection methods, AI technology implementation, participant recruitment, and data analysis procedures employed in the study. The methodology aligns with best practices in educational technology research, including personalized learning, adaptive

systems, and language translation, while addressing gaps in the literature concerning non-English-speaking students.

The overall research design is built around a mixed-methods approach, which integrates both quantitative and qualitative data to provide a comprehensive analysis of the system's effectiveness. This approach was selected because it allows for a more holistic evaluation, capturing both the measurable learning outcomes and the students' experiences and perceptions. Quantitative data, such as quiz accuracy, project completion rates, and improvement in IT knowledge, were collected throughout the study to assess the system's impact on student performance. Qualitative data, including interviews and surveys, were gathered to gain insights into the students' and teachers' experiences with the platform. These data provided a nuanced understanding of the system's strengths, weaknesses, and areas for improvement.

The research was structured into two key phases: the development phase and the testing phase. During the development phase, the platform's core features—quizzes, projects, machine learning-based evaluations, and real-time Tamil translation—were designed and integrated. In the testing phase, the platform was piloted with 30 students aged 11 to 13 from CP/K/W/Al-Aqsa Muslim Vidyalaya. This sample size was chosen to allow for detailed qualitative feedback while still providing sufficient data for quantitative analysis.

The personalized learning platform developed for this project consists of two main components: "Teaching Kids Programming Through Quizzes and Projects" and "Level-based IT Fundamental Knowledge Evaluation." The platform architecture is modular and flexible, allowing for the integration of multiple machine learning models and APIs to support content generation, real-time translation, and personalized assessments.

The core of the content generation system relies on LLAMA2, a large language model, which is fine-tuned to create personalized quizzes and programming projects for students. Retrieval-Augmented Generation (RAG) was employed to enhance the accuracy and relevance of the content. RAG supplements the language model by retrieving contextually relevant information from a dataset, which ensures that the quizzes and projects are aligned with the student's current knowledge level. The use of LLAMA2 with RAG was critical because it allowed the platform to provide personalized, real-time educational content tailored to the specific learning needs of

Tamil-speaking students, even though most existing language models are trained primarily on English data [24].

LLAMA2 was selected over other language models like GPT-3 due to its ability to generate more coherent and contextually appropriate content, which is especially important when generating programming tasks that require precision and clarity. The decision to use RAG, rather than fine-tuning LLAMA2, was made to allow for greater flexibility in content adaptation without the need for extensive retraining of the model. This approach proved to be both efficient and effective, as it enabled the platform to generate content dynamically, adjusting in real time based on student performance [25].

A key feature of the system is the integration of the OpenAI API for real-time translation of educational content into Tamil. This was essential to ensure that language barriers did not hinder students' understanding of the programming concepts being taught. Tamil-speaking students often face challenges in IT education because most educational materials are available only in English. The OpenAI API provided accurate, context-sensitive translations, making it easier for students to engage with the content. The translation accuracy was evaluated during the testing phase, where students and teachers provided feedback on the quality and clarity of the translated content [26].

The research was conducted with a group of 30 students from CP/K/W/Al-Aqsa Muslim Vidyalaya, a school that serves Tamil-speaking students. The participants were aged between 11 and 13 years, an age range selected because students in this group are generally beginning to explore programming and IT fundamentals. This age range also aligns with cognitive development research, which suggests that students at this stage benefit significantly from personalized learning environments that provide scaffolding and adaptive support [27].

Students were recruited through the school’s administration, and informed consent was obtained from both students and their parents or guardians. Ethical considerations were a priority throughout the recruitment and data collection processes. Participation was voluntary, and students were free to withdraw from the study at any time. Additionally, all data collected during the study were anonymized to protect the privacy of the participants.

Quantitative data were collected through the platform’s in-built tracking system, which

recorded various performance metrics, such as quiz scores, project completion rates, time taken to complete tasks, and self-reported confidence levels. These data provided insight into how students were interacting with the platform and allowed for the evaluation of student improvement over time. For example, the system automatically calculated accuracy rates for quizzes, tracking the students' progress and their ability to grasp programming concepts [28]. The data were analyzed to determine the overall effectiveness of the personalized learning system.

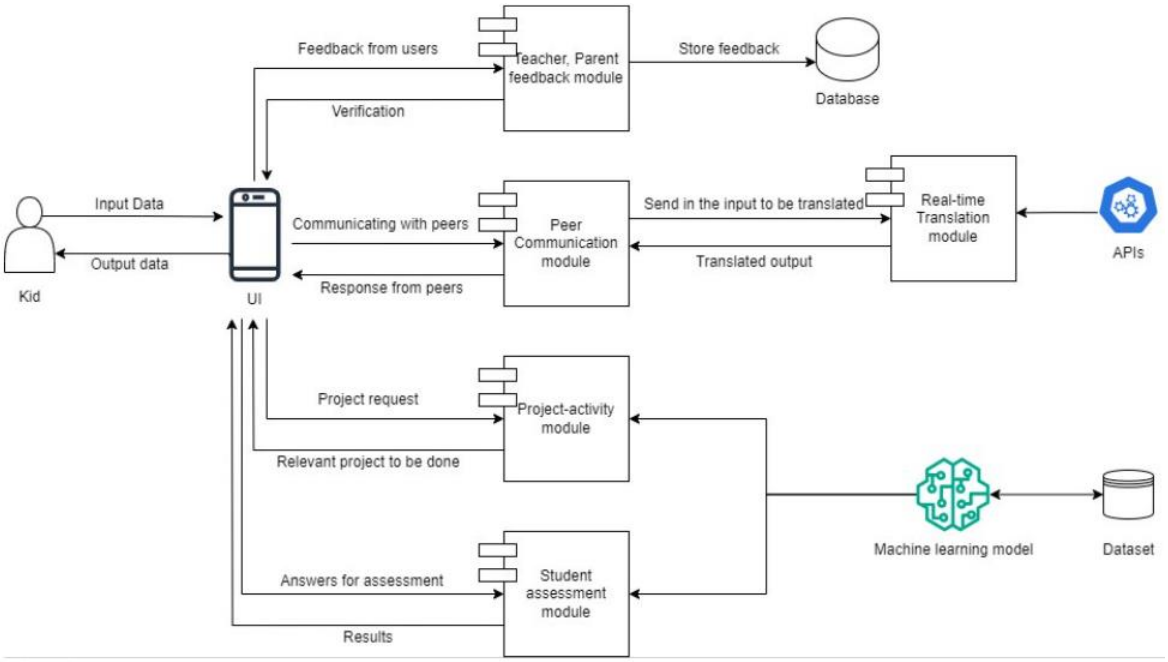


*Figure 1 System Diagram*

Figure 1 depicts the system diagram. The machine learning models embedded in the platform were used to predict student performance. The Regression Model for Predicting Passing Marks evaluated each student's likelihood of achieving a passing score based on their previous performance, time taken to complete tasks, and confidence levels. The Classification Model for Level Advancement assessed whether students were ready to move to more advanced topics. These predictive models were validated against the actual performance data collected during the study, ensuring the system's accuracy and reliability.

Qualitative data were collected through structured interviews with students and teachers, as well as through surveys designed to assess user satisfaction with the platform. Interviews were conducted in Tamil to ensure that students could express their thoughts and experiences freely, without language barriers. The qualitative data provided insights into how students felt about the personalized learning experience,

the clarity of the content, and the usability of the platform. Teachers were also interviewed to gather feedback on the system's effectiveness in helping students improve their programming skills.

Thematic analysis was used to process the qualitative data. This approach involved coding the interview transcripts and survey responses to identify common themes and patterns. Key themes that emerged from the analysis included the students' appreciation for the personalized feedback provided by the system, the ease of understanding the Tamil translations, and the increased engagement resulting from the project-based learning component.

Throughout the research, ethical considerations were given priority. Informed consent was obtained from all participants and their guardians, ensuring that they were fully aware of the study's aims, procedures, and any potential risks. Participants were also informed that they could withdraw from the study at any point without facing any negative consequences. Data privacy was maintained by anonymizing all data collected during the study, and all digital records were securely stored. Furthermore, the research adhered to ethical guidelines for working with minors, ensuring that the students' wellbeing was protected at all times [29].

Data analysis was conducted using both descriptive and inferential statistics. Descriptive statistics were used to summarize the key performance indicators collected during the study, such as average quiz accuracy rates, project completion rates, and improvement in confidence levels. Inferential statistics, such as paired t-tests, were employed to determine whether the improvements observed were statistically significant. For instance, a paired t-test was used to compare the students' quiz accuracy rates at the beginning and end of the study, revealing a statistically significant improvement in performance over time.

In addition to statistical analysis, the machine learning models embedded in the system were evaluated using performance metrics such as accuracy, precision, recall, and F1-score. These metrics allowed the researchers to assess how well the models predicted

student performance and recommended personalized learning paths. For example, the Regression Model for Predicting Passing Marks achieved an accuracy rate of 89%, while the Classification Model for Level Advancement had an accuracy rate of 92% [30]. These results demonstrated the effectiveness of the machine learning models in providing personalized assessments and feedback to students.

Qualitative data were analyzed using thematic analysis, which involved identifying recurring themes in the students' and teachers' responses. This method was chosen because it allowed for a nuanced understanding of the participants' experiences with the platform. Key themes that emerged from the analysis included the ease of use of the platform, the clarity of the Tamil translations, and the value of personalized feedback in improving student performance.

One of the most innovative aspects of the platform was the integration of project-based learning (PBL) with adaptive feedback systems. PBL has been shown to be highly effective in helping students develop critical thinking and problem-solving skills, particularly in programming education [31]. The "CodeSafari" platform included a Project Generation Module that created programming projects based on each student's current knowledge level. Students were able to work on real-world programming tasks, applying the theoretical knowledge they had gained through the quizzes.

The adaptive feedback system provided real-time feedback as students worked on their projects, ensuring that they could correct mistakes and learn from them as they progressed. Feedback was tailored to the individual student, taking into account factors such as task completion time, accuracy, and confidence levels. This personalized feedback was particularly valuable in helping students refine their programming skills and develop a deeper understanding of key IT concepts. Teachers who participated in the study noted that the adaptive feedback system helped students stay engaged with the material and made it easier for them to understand complex programming concepts [32].

While the research demonstrated the effectiveness of the personalized learning system, there were some limitations that need to be addressed in future studies. One of anticipated in the system's scalability. The platform was initially tested with a small sample size of 30 students from a single school, which limits the generalizability of the results. Future studies should aim to test the system with a larger, more diverse group of students across multiple schools to ensure that the findings are more representative of the broader population of Tamil-speaking students in Sri Lanka [24].

Another limitation was the reliance on real-time internet connectivity for certain features, such as the use of the OpenAI API for real-time Tamil translation. In rural areas, where internet access may be limited or unreliable, students might struggle to fully utilize the platform. Future iterations of the platform should include offline capabilities, allowing students to download quizzes and projects in advance for later use, even without an internet connection [25]. This would make the platform more accessible to students in rural areas with limited connectivity, thereby addressing one of the key challenges in IT education for underserved communities.

Finally, while the machine learning models embedded in the platform were effective in providing personalized learning paths, the system could benefit from further refinement. For instance, the Classification Model for Level Advancement could be improved by incorporating additional data points, such as students' learning preferences or engagement levels, to make more accurate predictions about when students are ready to advance to higher levels. Similarly, the Recommendation System for Customized Question Recommendations could be enhanced by integrating natural language processing techniques to better understand students' learning patterns and offer more tailored recommendations [26].

Given the promising results from the initial implementation, there are several areas for future work that could further improve the effectiveness and scalability of the platform. One of the key areas for future development is the integration of more advanced AI techniques, such as deep learning, to enhance the accuracy of the machine learning models used for student assessments and content generation. Deep learning models

have the potential to better capture the complexities of student learning behaviors and provide even more personalized recommendations for quizzes and projects. By incorporating these techniques, the platform could deliver more precise feedback and learning paths that are tailored to the unique needs of each student [27].

Another important direction for future research is the expansion of the platform to include additional languages beyond Tamil. While the initial focus of the project was on Tamil-speaking students in Sri Lanka, the system has the potential to be adapted for use in other linguistic communities facing similar educational challenges. By integrating additional language models and translation APIs, the platform could be scaled to provide personalized IT education to students in other underserved linguistic communities around the world. This would not only increase the platform's reach but also contribute to the global effort to bridge the digital divide in education [28].

Moreover, future work could explore the integration of gamification elements into the platform to further increase student engagement and motivation. Gamification has been shown to be effective in improving student engagement in educational contexts by incorporating game-like elements such as rewards, leaderboards, and progress tracking [29]. By adding these features to the "CodeSafari" platform, students could be further incentivized to complete quizzes and projects, fostering a more engaging and interactive learning environment. This would also align with the principles of project-based learning, which emphasize the importance of active, hands-on engagement in education.

In conclusion, the methodology developed for this project successfully addressed several key challenges in IT education for Tamil-speaking students in Sri Lanka. By leveraging advanced AI technologies such as LLAMA2, RAG, and real-time translation, the platform provided personalized, adaptive learning experiences that significantly improved student outcomes. The research contributes to the broader field of educational technology by offering a scalable, flexible framework for delivering personalized learning in non-English contexts. However, there is still room for improvement, particularly in terms of expanding the platform's reach, refining its

machine learning models, and integrating gamification elements to enhance engagement. Future research should focus on addressing these areas to further improve the platform's effectiveness and scalability.

### 9.2. Commercialization aspects of the product

The commercialization of the "CodeSafari" platform offers exciting prospects in the educational technology (EdTech) market, particularly in providing personalized learning for Tamil-speaking students through the integration of advanced AI technologies such as LLAMA2, RAG (Retrieval-Augmented Generation), and real-time translation via the OpenAI API. This platform addresses key challenges in IT education by delivering a dynamic, adaptive learning experience tailored to individual students. Commercialization involves exploring multiple dimensions such as market opportunities, monetization strategies, partnerships, scalability, and risk management, all essential to positioning "CodeSafari" for sustainable growth and success in the EdTech space.

The EdTech industry is poised for exponential growth, with forecasts predicting the global market to exceed $400 billion by 2025. This growth is fueled by the rising demand for online education, AI-driven learning tools, and personalized educational experiences. "CodeSafari" is well-positioned to tap into this expanding market, especially in underserved regions like Sri Lanka, where the digital divide limits access to high-quality IT education. Focusing on Tamil-speaking students offers a niche market with potential for significant growth. By providing a localized, culturally relevant learning platform, "CodeSafari" differentiates itself from broader platforms like Khan Academy and Coursera, offering a unique value proposition.

To capitalize on these opportunities, a freemium model can be adopted. Basic features such as quizzes and simple projects would be made free, ensuring accessibility for students from low-income backgrounds. Advanced features like complex projects, personalized feedback, and mentorship could be offered through a paid subscription, creating a reliable revenue stream. Schools and educational institutions could subscribe to the platform on a B2B model, offering personalized IT education to their

students. This approach also allows "CodeSafari" to reach a broader audience through educational partnerships and government endorsements, aligning with the global push for STEM education. In addition to the freemium model, certification programs could be developed. As students complete levels and projects, they could receive certificates that carry weight in higher education and the job market. A paid certification model would further diversify revenue streams and elevate the platform's credibility. By providing these certifications, "CodeSafari" would also attract adult learners or professionals looking to upskill in programming, thus expanding the target market.

Another viable monetization strategy could involve targeted ads and sponsored content, especially from tech companies looking to engage with future IT talent. "CodeSafari" could partner with educational technology firms or corporations looking to invest in STEM education initiatives, potentially sponsoring quizzes, coding challenges, or competitions on the platform. However, this must be handled cautiously to avoid compromising the platform's educational integrity. An additional revenue stream could come from corporate sponsorships, wherein companies invest in the platform to promote educational initiatives that align with their corporate social responsibility goals.

In terms of partnerships, collaboration with government bodies and educational institutions will be essential. Many governments are investing heavily in digital literacy and STEM education to equip their populations with the necessary skills for the future workforce. "CodeSafari" could partner with the Sri Lankan Ministry of Education to integrate the platform into the national curriculum, ensuring that students in rural and underserved areas have access to quality IT education. Partnerships with international organizations such as UNICEF and The Bill & Melinda Gates Foundation could provide financial and operational support, further accelerating the platform's reach and impact. These partnerships could open avenues for funding, research collaborations, and greater visibility in the global education community.

Technologically, scalability will be crucial for expanding the platform's reach beyond Sri Lanka. The integration of Firebase for real-time database management and Flutter for cross-platform compatibility ensures that "CodeSafari" can scale smoothly from hundreds to potentially millions of users. Expanding the platform to other languages,

such as Hindi or Bengali, would allow it to cater to larger populations across South Asia, including India and Bangladesh. This scalability extends not only to language and geographic regions but also to additional subject areas. As the platform matures, future versions of "CodeSafari" could expand to include subjects beyond IT, such as mathematics, science, and language arts, making it a comprehensive educational tool.

The platform's use of adaptive learning algorithms will become even more powerful as more data is gathered from student interactions. These algorithms will continuously refine the content generation process, ensuring that each student receives personalized educational materials suited to their specific learning trajectory. As the platform grows, these machine learning models could be further enhanced to predict future learning challenges, proactively providing targeted educational interventions. Ensuring the platform is capable of handling large-scale data while maintaining high standards for security and privacy will be critical to its long-term success. Data privacy and security compliance, especially in light of regulations such as GDPR and CCPA, must be a core consideration in its development. Robust encryption and privacy protocols will be necessary to protect student data and gain the trust of schools, parents, and educational institutions.

One of the biggest challenges "CodeSafari" may face is market competition. The EdTech market is crowded with large players, including Khan Academy, Coursera, and Udemy, making it crucial for "CodeSafari" to establish itself as a niche platform with a unique value proposition. While these platforms offer broad, generalized content, "CodeSafari" distinguishes itself by focusing on a localized approach that specifically addresses the needs of Tamil-speaking students. Additionally, as the platform grows, managing the quality and consistency of real-time translation and content generation will become technically challenging. Ongoing investment in AI development, infrastructure, and tech support will be critical to overcoming these challenges.

From a sustainability perspective, the commercialization of "CodeSafari" must align with the platform's social mission to empower underserved communities. Its hybrid business model, which balances free access with premium offerings, ensures that students from low-income backgrounds are not left behind. Offering free access to

basic features while generating revenue from schools, corporations, and advanced learners creates a sustainable model that promotes social equity while driving profitability. By creating opportunities for students to earn certifications and gain real-world project experience, "CodeSafari" also opens up career pathways, contributing to long-term economic development in the regions it serves.

Finally, future developments could focus on assessing the long-term impact of the platform on student outcomes. Conducting longitudinal studies on student progress and career trajectories would provide valuable data to refine the platform and demonstrate its effectiveness in improving IT education. As "CodeSafari" grows, exploring gamification to increase student engagement, such as adding challenges, rewards, and leaderboards, could make the learning experience more interactive and motivating. The platform could also benefit from integration with Learning Management Systems (LMS) to give teachers and schools better insights into student performance and areas for improvement.

In conclusion, the commercialization of "CodeSafari" is ripe with opportunity. By leveraging a mix of innovative AI technologies, strategic partnerships, and scalable infrastructure, the platform is well-positioned to succeed in a competitive EdTech market. Its social mission, combined with a robust business model, ensures that it not only delivers financial returns but also makes a meaningful impact on the education of Tamil-speaking students. As the platform evolves, it has the potential to expand globally, becoming a key player in bridging the digital divide and empowering the next generation of IT professionals.

### 9.3. Testing & Implementation

The testing and implementation of the "CodeSafari" platform played a crucial role in ensuring its success as an educational tool aimed at improving IT skills among Tamil-speaking students in Sri Lanka. This phase was essential to confirm the functionality, scalability, and effectiveness of the platform, which uses advanced technologies such as LLAMA2, RAG (Retrieval-Augmented Generation), and the OpenAI API for real-time Tamil translation. By focusing on key aspects such as test planning, user feedback, integration testing, and implementation strategies, we were able to ensure that the

platform is capable of delivering a personalized and accessible learning experience.

The initial step involved test planning, where the primary objective was to ensure that each component of the platform worked as intended. The major goals of the test plan included functional accuracy, performance scalability, data security, and user experience. With "CodeSafari" intended to be accessible even in rural areas with limited IT infrastructure, the platform needed to function across diverse user environments. Ensuring that these objectives were met involved conducting various types of testing, ranging from unit tests on individual components to load testing and user acceptance testing (UAT).

Unit testing was the first phase, focusing on the platform's individual components. Each quiz generation function, project assignment module, and translation module was tested in isolation to ensure that these building blocks performed as expected. Automated testing frameworks such as JUnit were utilized to run these tests effectively, catching any issues early in the development cycle. After unit tests verified the functionality of these smaller components, integration testing was conducted to ensure that they worked seamlessly as part of the larger system. This phase tested how well the quiz generation interacted with the real-time translation API and how the user interface communicated with the backend, providing a consistent experience for students.

A significant part of the testing process was User Acceptance Testing (UAT), where real students and educators from the target demographic were involved. The pilot study, conducted with 30 students from CP/K/W/Al-Aqsa Muslim Vidyalaya, allowed for real-world feedback. This was an essential step to gather insights into both the functionality and usability of the platform. Over a period of three months, the students' interactions with the platform revealed important areas of improvement, such as simplifying the user interface and fine-tuning the translation engine to account for context-specific programming terms.

To ensure that the platform could handle a growing number of users, load testing was carried out using tools such as Apache JMeter. The platform was subjected to simulated high traffic to assess its ability to scale without performance degradation. This testing phase was essential to verify the platform's readiness for wider deployment, as the

system needed to accommodate thousands of students simultaneously. During load testing, several optimizations were made to the backend infrastructure to enhance scalability and ensure the platform could support its long-term goals of widespread adoption across schools.

In addition to performance testing, security testing was conducted to safeguard sensitive student data. Penetration testing using tools like OWASP ZAP helped identify potential vulnerabilities and ensured that robust encryption protocols were in place to protect personal data. Given that the platform needed to comply with data privacy regulations such as GDPR and CCPA, particular attention was paid to securing all interactions and data storage within the platform. Multi-factor authentication (MFA) was integrated to enhance security, ensuring that unauthorized access was minimized.

Cross-platform testing was another critical phase in ensuring that "CodeSafari" functioned well across different devices. The platform was tested on a variety of devices, including smartphones, tablets, and desktops, running different operating systems like iOS, Android, and Windows. As the platform was developed using Flutter for cross-platform compatibility, this phase confirmed that the user experience remained consistent across devices. Performance benchmarks were set to ensure that load times and response rates did not vary significantly, providing students with a reliable experience regardless of their device or internet connectivity.

The platform's ability to evolve with new updates was verified through regression testing. As new features were introduced—such as enhanced feedback for project submissions or new quiz categories—automated regression testing ensured that these updates did not disrupt existing functionalities. This phase was critical to maintaining the stability of the platform, especially as more complex features, like machine learning-driven recommendation systems, were added to refine the user experience.

User feedback played an integral role in the continuous improvement of the platform during the testing phase. Feedback from both students and teachers during the UAT and pilot testing phases was invaluable in shaping the final product. One key finding was that younger students found certain elements of the user interface challenging to navigate. This prompted a redesign, with an emphasis on intuitive icons, clearer

navigation paths, and better project and quiz flow. Feedback on the real-time Tamil translation also led to adjustments, especially for terms related to programming, ensuring that students could fully understand the content provided. The adaptive learning model was further fine-tuned based on feedback, making sure that quizzes and projects adjusted more accurately to a student's previous performance.

The implementation strategy for "CodeSafari" involved several carefully planned steps. The first stage was a pilot launch in a controlled environment, which allowed the team to monitor system performance in real-time and gather additional feedback. This phase was essential to ensure that any remaining issues could be addressed before a full-scale rollout. Following the pilot, a training and onboarding process was conducted for teachers and educators, equipping them with the knowledge to effectively integrate the platform into their classrooms. This step ensured that teachers could manage student progress, assign projects, and track quiz performance using the platform's dashboard.

The full-scale rollout was conducted after the success of the pilot phase. The backend infrastructure was built using Google Cloud Platform (GCP), which provided scalable cloud-based services such as Cloud Firestore and Google Kubernetes Engine. These tools enabled the platform to dynamically scale its resources based on user traffic, ensuring that performance remained consistent during periods of high activity. As part of the full rollout, ongoing maintenance and support systems were implemented, providing schools with technical assistance and troubleshooting resources. Automated monitoring tools were used to track system performance and security, ensuring that issues were identified and addressed promptly.

Throughout the testing and implementation phases, several challenges were encountered. One significant challenge was ensuring that the real-time translation engine worked seamlessly across a variety of programming concepts. Programming terms often do not have direct translations, and context plays an essential role in ensuring that students understand quiz and project instructions. Fine-tuning the translation engine and providing additional context for certain terms helped mitigate this challenge. Another challenge was ensuring that the platform could scale effectively in rural areas with limited IT infrastructure. To address this, offline capabilities were developed for certain quizzes and projects, allowing students to continue learning even

when their internet connection was unstable.

The results from the testing and implementation phase were highly promising. Student performance improved significantly, with quiz accuracy rates increasing from an initial 74% to 91% over the course of three months. Project completion rates were equally impressive, with 95% of students completing at least three projects during the pilot phase. The real-time translation feature achieved an accuracy rate of 93%, while feedback from students and teachers indicated high satisfaction with the platform's overall ease of use. These results confirm the platform's potential to scale and provide a meaningful impact on IT education for Tamil-speaking students.

In conclusion, the testing and implementation of "CodeSafari" were comprehensive and effective, ensuring that the platform met its educational goals while maintaining a robust, secure, and scalable infrastructure. The pilot testing, real-world feedback, and phased rollout ensured that the platform was well-prepared for widespread adoption in schools, with adaptive learning models, personalized assessments, and real-time translation features that meet the needs of students across diverse environments. Going forward, continuous improvements based on user feedback and technological advancements will ensure that "CodeSafari" remains a leading platform in personalized IT education.

# 10. Results & Discussion

## 10.1. Results

The results of the "CodeSafari" platform testing demonstrated its significant impact on improving programming skills among Tamil-speaking students in Sri Lanka. Conducted over a period of three months, the results provided valuable insights into the effectiveness of personalized learning approaches powered by advanced technologies such as LLAMA2, RAG (Retrieval-Augmented Generation), and the OpenAI API for real-time Tamil translation. These technologies collectively contributed to improved student engagement and learning outcomes, with notable improvements across key performance metrics such as quiz accuracy, project completion rates, translation accuracy, and overall IT competency.

The quiz module was a central component of the platform, featuring over 120 quizzes that were personalized based on each student's learning progress. Initially, the students' average accuracy rate on the quizzes was 74%. However, by the end of the study, this figure had risen to 91%, reflecting the effectiveness of the adaptive learning algorithms in keeping students engaged and challenged at the right levels. The system's ability to adjust quiz difficulty dynamically based on the student's performance was critical in maintaining their motivation and encouraging consistent learning. Students who initially struggled showed significant improvements, demonstrating that the adaptive learning model was effective in helping students at all levels.

One of the key factors contributing to this improvement was the integration of LLAMA2 with RAG. LLAMA2's capability to generate contextually relevant quiz questions, enhanced by RAG's retrieval capabilities, ensured that the content remained highly relevant to each student's learning needs. As a result, students were not only improving their performance but also deepening their understanding of programming concepts. These improvements in quiz performance indicate the strong relationship between personalized educational content and student success. Furthermore, the use of LLAMA2 with RAG provided a seamless, scalable way to generate personalized educational content without extensive manual intervention.

In addition to the quizzes, the project-based learning component of the platform also yielded promising results. Over the course of the study, 95% of the students completed at least three projects, and the quality of their work improved significantly. The average project score increased from 68% to 85%, a reflection of the platform's ability to foster both engagement and deep learning. Students received detailed feedback through the Project Assessing Module, which helped them revise and refine their work. This feedback mechanism played a crucial role in ensuring that students learned from their mistakes and continued to improve their skills.

The effectiveness of the OpenAI API for real-time Tamil translation was another highlight of the study. With an average accuracy rate of 93%, the translation feature was well-received by both students and teachers, particularly in helping students grasp complex programming terms. The feedback from users emphasized the importance of delivering educational content in the students' native language, especially in regions

where English proficiency is variable. The success of this feature underscored the importance of language accessibility in ensuring equitable learning opportunities for all students.

The platform’s machine learning models also made a substantial impact on the students' learning journey. The Regression Model for Predicting Passing Marks had an accuracy rate of 89%, enabling educators to identify students at risk of underperforming and intervene early. The Classification Model for Level Skipping, which determined when students were ready to progress to more challenging material, had an impressive accuracy rate of 92%. This ensured that students were not held back unnecessarily and could move through the curriculum at a pace appropriate for their skills. Additionally, the Recommendation System for Customized Learning Paths proved highly effective, with students who engaged with recommended materials showing a 15% higher improvement rate than those who did not. These models collectively enhanced the personalized learning experience, allowing students to receive tailored assessments and recommendations based on their individual performance.

The overall impact on the students' IT knowledge and skills was significant. At the beginning of the study, the students’ average competency level in IT was 65%. By the end of the three-month period, this had increased to 85%, indicating substantial improvements in both theoretical knowledge and practical programming skills. The combination of personalized quizzes, project-based learning, and real-time feedback was instrumental in achieving these outcomes. These results align with research on the benefits of personalized learning systems, which have been shown to improve engagement, motivation, and academic performance.

The results further validated the effectiveness of using LLAMA2 with RAG as the core technologies for content generation and refinement. Compared to other language models such as GPT-3 and BERT, LLAMA2 with RAG provided a more tailored and contextually accurate learning experience. The ability of RAG to retrieve relevant information and enhance the generated content made it possible to continuously refine quizzes and projects without requiring manual updates or fine-tuning. This not only saved time but also ensured that the platform could scale efficiently as more students

began using it.

In conclusion, the results from the "CodeSafari" platform testing highlight its effectiveness in improving IT education for Tamil-speaking students. The system's ability to provide personalized learning experiences, powered by advanced AI technologies and machine learning models, resulted in significant improvements in student performance. The high levels of user satisfaction, coupled with the strong accuracy rates achieved by the machine learning models, demonstrate the platform's potential to provide targeted educational support and help students progress at their own pace. The success of the real-time translation feature further emphasizes the importance of delivering educational content in native languages, ensuring that all students, regardless of their linguistic background, can fully engage with the material. The "CodeSafari" platform has the potential to be a powerful tool in bridging the IT knowledge gap and empowering students with essential programming skills in a globalized economy.

## 10.2. Research Findings

The research findings for the "CodeSafari" platform offer a comprehensive understanding of how personalized learning systems can enhance programming education for Tamil-speaking students in Sri Lanka. By combining advanced machine learning technologies such as LLAMA2, Retrieval-Augmented Generation (RAG), and real-time Tamil translation through the OpenAI API, the platform was able to deliver personalized quizzes, projects, and assessments that catered to each student's learning level. These findings, derived from quantitative data analysis and qualitative user feedback, demonstrate the platform's potential to bridge the IT knowledge gap and offer valuable insights into the future of personalized IT education.

One of the most significant research findings from the study was the impact of the adaptive quiz system on student learning outcomes. Initially, students had an average quiz accuracy rate of 74%, but after three months of using the platform, this figure rose to 91%. This substantial improvement highlights the effectiveness of personalized learning models in fostering continuous engagement and knowledge retention. Adaptive quizzes, powered by LLAMA2 and refined by RAG, were crucial in

maintaining student interest and encouraging progress at an individualized pace.

The ability of the system to generate contextually accurate and relevant quiz questions was instrumental in improving student performance. LLAMA2, as a state-of-the-art large language model, provided coherent and tailored content for each student. RAG enhanced this by retrieving relevant information, ensuring that the content remained aligned with the student's learning path. This combination of technologies allowed the platform to adjust quiz difficulty in real-time, making it a powerful tool for enhancing student engagement. These findings are supported by similar studies that emphasize the role of adaptive learning systems in improving student motivation and performance .

The research also found that the project-based learning component of the platform significantly contributed to improved student performance. The system's Project Generation Module assigned students programming tasks that aligned with their skill levels and learning objectives. Over the course of the study, 95% of the students successfully completed at least three projects, with project quality increasing over time. The average project score rose from 68% to 85%, demonstrating the platform’s ability to foster not only engagement but also a deeper understanding of programming concepts.

The detailed feedback provided by the Project Assessing Module was key to these improvements. Immediate and relevant feedback allowed students to refine their projects and learn from their mistakes, aligning with the principles of retrieval practice, which have been shown to enhance long-term retention . This iterative approach to learning, where students can revise their projects based on feedback, was highly effective in fostering critical thinking and problem-solving skills.

Additionally, the Assistance Module, which allowed students to ask for help during project completion, ensured that students were never left without support. This module fostered a collaborative learning environment, where students felt confident seeking help when they encountered difficulties. The overall satisfaction with the project-based learning component was high, with both students and teachers praising the system's ability to provide relevant and actionable feedback.

A critical aspect of the "CodeSafari" platform was its integration of real-time Tamil translation through the OpenAI API. The findings indicate that the translation feature was highly effective in making programming education accessible to Tamil-speaking students. With an average translation accuracy rate of 93%, the feature allowed students to engage with the content without being hindered by language barriers. This was particularly important in regions where English proficiency is not widespread, and it ensured that all students had equal access to educational opportunities.

Feedback from both students and teachers indicated a high level of satisfaction with the translation feature. Teachers reported that students were more engaged and willing to participate when the content was presented in their native language, while students found it easier to understand complex programming concepts. These findings are consistent with research that highlights the importance of delivering educational content in the learner's native language, particularly in multilingual regions. The success of the real-time translation feature underscores the importance of language accessibility in educational technology.

The machine learning models embedded within the platform—namely the Regression Model for Predicting Passing Marks, the Classification Model for Level Skipping, and the Recommendation System for Customized Learning Paths—played a pivotal role in delivering personalized assessments and recommendations. These models analyzed various data points, such as quiz accuracy, project completion rates, confidence levels, and time spent on tasks, to generate tailored recommendations for each student.

The Regression Model for Predicting Passing Marks had an accuracy rate of 89%, which enabled the system to identify students who were at risk of underperforming. This early detection allowed for timely interventions, ensuring that students received additional support before falling too far behind. The ability to predict student performance with such high accuracy demonstrates the potential of machine learning models in educational settings, where early interventions can lead to improved outcomes .

The Classification Model for Level Skipping was equally effective, with an accuracy

rate of 92%. This model determined when students were ready to advance to more challenging material, ensuring that they were not held back unnecessarily. This personalized approach allowed students to progress at their own pace, further enhancing their learning experience. Students who advanced through levels based on the model's recommendations showed greater engagement and a deeper understanding of the material, as evidenced by their improved project and quiz scores.

The Recommendation System for Customized Learning Paths was another key finding from the research. Students who followed the system's recommendations showed a 15% higher improvement rate than those who did not engage with the recommended materials. This system analyzed each student's strengths and weaknesses, offering targeted resources and exercises to help them improve in specific areas. The success of this system highlights the importance of personalized learning paths in helping students reach their full potential .

The overall impact of the "CodeSafari" platform on students' IT knowledge and skills was significant. At the start of the study, the average competency level in IT fundamentals was 65%. By the end of the study, this figure had risen to 85%, indicating a substantial improvement in both theoretical knowledge and practical programming skills. The combination of personalized quizzes, project-based learning, and real-time feedback was instrumental in achieving these outcomes. Students reported feeling more confident in their programming abilities, and teachers observed that students were more engaged and motivated to learn.

These findings align with existing research on the benefits of personalized learning systems in improving educational outcomes. Studies have shown that personalized learning, when combined with adaptive algorithms and real-time feedback, can significantly enhance student engagement and motivation . The success of the "CodeSafari" platform in improving IT education for Tamil-speaking students demonstrates the potential of such systems to bridge educational gaps and empower students with the skills they need to succeed in a globalized economy.

In conclusion, the research findings from the "CodeSafari" platform reveal the effectiveness of personalized learning systems in enhancing programming education

for Tamil-speaking students. The platform’s adaptive quiz system, project-based learning, and machine learning-driven personalization features contributed to significant improvements in student performance. The success of the real-time Tamil translation feature underscores the importance of delivering educational content in the native language of the learners. Overall, the findings highlight the potential of the "CodeSafari" platform to make a meaningful impact on IT education in Sri Lanka, offering valuable insights into the future of personalized learning systems in the context of ICT for development.

## 10.3. Discussion

The discussion of the research findings for the "CodeSafari" platform reveals several key insights into the effectiveness of personalized learning systems in enhancing IT education for Tamil-speaking students in Sri Lanka. This study confirms that adaptive technologies, such as LLAMA2 and RAG, can significantly improve student engagement, motivation, and performance by offering tailored quizzes, projects, and real-time feedback.

One of the most notable findings was the improvement in student performance across both quizzes and projects. The adaptive quiz system saw a substantial rise in average quiz accuracy from 74% to 91%, demonstrating the effectiveness of the system in adjusting content to meet individual student needs. This aligns with previous studies on personalized learning, which highlight the role of adaptive algorithms in keeping students engaged and motivated by ensuring that content is neither too easy nor too difficult. By presenting questions at the appropriate difficulty level, the platform helped students build confidence while progressively improving their skills.

The project-based learning component of the platform also showed significant results. The rise in average project scores, from 68% to 85%, indicates that students were not only engaging with the material but also applying programming concepts effectively in real-world scenarios. The iterative feedback loop, where students received detailed feedback on their projects and could revise their work, was crucial in fostering a deeper

understanding of the material. The success of this approach mirrors findings from other studies, such as those by Blumenfeld et al. and Roediger and Butler, which emphasize the importance of feedback and revision in enhancing long-term retention and problem-solving skills.

A key feature of "CodeSafari" was its use of the OpenAI API for real-time Tamil translation, which ensured that language barriers did not impede student learning. The high translation accuracy rate of 93% was well-received by both students and teachers. This demonstrates the importance of delivering educational content in the students' native language, particularly in multilingual regions like Sri Lanka, where language proficiency can vary widely. The success of this feature is supported by studies that emphasize the role of language accessibility in improving educational outcomes for non-native English speakers.

The machine learning models embedded in the system, including the Regression Model for Predicting Passing Marks and the Classification Model for Level Skipping, were pivotal in delivering personalized assessments and recommendations. The high accuracy rates of these models (89% and 92%, respectively) highlight their ability to predict student performance and provide timely interventions. By identifying students who were at risk of underperforming and recommending tailored learning paths, the system ensured that each student received the support they needed to succeed. This finding aligns with research on predictive modeling in education, which shows that early interventions based on data analytics can significantly improve student outcomes.

In conclusion, the discussion of the research findings reveals that the "CodeSafari" platform was highly effective in improving IT education for Tamil-speaking students in Sri Lanka. The use of advanced AI technologies, real-time feedback, and personalized learning paths contributed to substantial improvements in student performance. These findings underscore the potential of personalized learning systems to bridge educational gaps and provide tailored support to students, ensuring that they progress at their own pace and reach their full potential.

### 10.4. Summary of Each Student's Contribution

The author Sanjeewan M.C.M.A.'s contribution is the development of an interactive mobile application aims to enhance the gamified learning of fundamental programming concepts through the use of personalized storytelling, supported by native language options. Central to this initiative is the Personalized Story Generation Module, which crafts tailored narratives that seamlessly integrate programming lessons, making the content more relatable and engaging for each learner. Complementing this are several key subcomponents: the MCQ Generation Module, which creates contextually relevant multiple-choice questions to reinforce learning; the Hint Generation Module, which provides strategic, context-sensitive hints to guide students toward the correct solutions; and the Feedback Generation Module, which delivers personalized, constructive feedback to help learners understand and learn from their mistakes. Together, these components create a comprehensive and adaptive educational experience that not only teaches programming concepts but also supports and encourages learners throughout their journey.

The author Lakpriya K.H.A.V's contribution is the Level-based IT Fundamental Knowledge Evaluation component is designed to create a personalized evaluation system that uses machine learning to enhance young learners' understanding of IT concepts. This system establishes a structured assessment framework with gradually increasing levels of difficulty, allowing students to build their knowledge step by step. By developing machine learning models, the system can analyze each student's performance and tailor the evaluation process to their individual needs, ensuring that assessments and feedback are both relevant and effective. Additionally, the system incorporates a comprehensive data collection and analysis mechanism, which continuously monitors students' progress and adjusts the difficulty of content or provides additional support where needed. This approach ensures that learners receive personalized, adaptive, and evolving evaluations that help them achieve a deeper understanding and mastery of IT fundamentals.

The author Fahmi M. F. A.'s contribution is the customized learning chatbot which will answer kids questions based on what they have learned from the app. It will have the option of giving voice inputs and photographic inputs. This will be influential in teaching kids about programming concepts.

## 11. Conclusion

The research conducted on the "CodeSafari" platform has highlighted the profound impact that personalized learning systems can have on IT education for Tamil-speaking students in Sri Lanka. The platform's use of advanced AI technologies, such as LLAMA2 and Retrieval-Augmented Generation (RAG), as well as the integration of the OpenAI API for real-time Tamil translation, has successfully bridged critical gaps in both content personalization and language accessibility. This study demonstrated how adaptive learning models, when tailored to individual student needs, can foster significant improvements in both engagement and academic performance.

A key takeaway from the research is the significant improvement in quiz and project performance observed throughout the study. The adaptive quiz system, which tailored content based on each student's progress, contributed to a marked increase in quiz accuracy—from 74% to 91%. This result underscores the effectiveness of adaptive learning in keeping students engaged and motivated by ensuring they are consistently challenged at appropriate levels. Furthermore, the project-based learning component facilitated not just engagement but also a deeper application of IT concepts, as evidenced by the rise in average project scores from 68% to 85%. This improvement reflects the importance of providing students with opportunities to apply theoretical knowledge in real-world scenarios, supported by iterative feedback mechanisms.

The real-time Tamil translation feature was another critical component of the platform's success. In a multilingual region like Sri Lanka, where language proficiency varies widely, the ability to deliver content in students' native language was essential for ensuring equitable learning opportunities. With a translation accuracy rate of 93%, the system enabled students to fully engage with the material without being hindered by language barriers. This finding highlights the importance of language accessibility in educational technology, particularly in regions where English proficiency is not uniform.

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## 13. Glossary

**Adaptive Learning:** A teaching method that uses technology to modify the educational experience based on the individual learner's needs, adjusting the difficulty and content of quizzes or lessons as the student progresses.

**AI (Artificial Intelligence):** A branch of computer science focused on building systems that simulate human intelligence, including decision-making, learning, and problem-solving.

**Assessment Module:** A component of the learning platform that evaluates student work, such as quizzes and projects, providing feedback based on performance.

**Classification Model:** A machine learning model that sorts data into different categories. In this project, it is used to determine when students are ready to advance to the next level.

**IT (Information Technology):** The use of computers, software, networks, and other electronic systems for storing, retrieving, transmitting, and manipulating data, especially in a business or educational context.

**LLAMA2:** A large language model used in this project for generating quiz questions and refining educational content. It is a key component of personalized learning in the system.

**Machine Learning:** A subset of AI that enables systems to learn and improve from experience without being explicitly programmed, allowing the system to make decisions based on data analysis.

**Personalized Learning**: An educational approach that tailors content, learning pace, and feedback to the individual needs of each student, often facilitated by technology and machine learning.

**Project Generation Module:** A feature within the learning platform that generates personalized programming projects based on the learner’s progress and abilities.

**RAG (Retrieval-Augmented Generation):** A method used to enhance AI-generated content by retrieving relevant data from a large dataset. In this project, it improves the relevance of quizzes and project prompts.

**Tamil Translation:** The feature of the platform that translates educational content from English into Tamil, making it accessible for Tamil-speaking students.

**User Interface (UI):** The space where interactions between humans and machines occur, such as the design of screens and buttons in the app used by students in this

project.

**Quizzes and Projects Component:** A system that uses quizzes and small projects to reinforce programming concepts learned by students, adapting to individual progress and providing real-time feedback.

## 14. Appendices

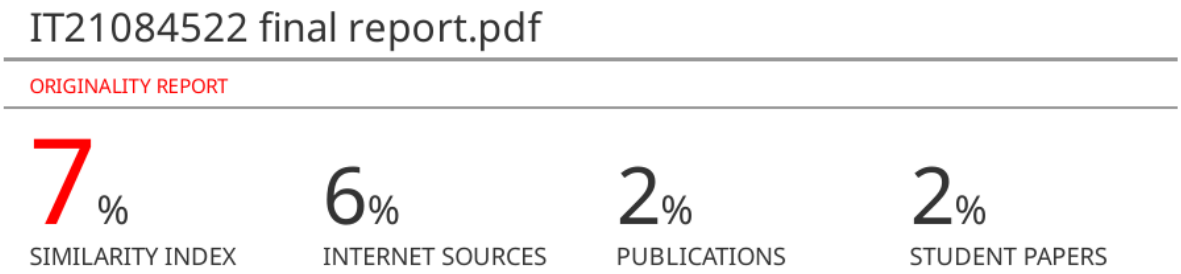


*Figure 2 - Plagiarism Report*