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RESEARCH TITLE:-

ASSESSING E-LEARNING PLATFORMS IN TVET COLLEGES 'PROPOSING A FRAMEWORK

A research Submitted in Partial Fulfilment of the Requirements for the Degree of

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY

By:

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Addis Ababa, Ethiopia

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FDRE TECHNICAL AND VOCATIONAL TRAINING INSTITUTE
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Principal Advisor: Dr. Hailay

Addis Ababa, Ethiopia

May , 2026

DECLARATION

I, the undersigned, declare that this dissertation entitled **"assessing e-learning platforms in TVET colleges 'proposing a framework"** is my own original work, prepared under the supervision of my advisor(s). It has not been submitted for the award of any degree, diploma, or any other academic qualification in this or any other institution. All sources of materials used in this dissertation have been duly acknowledged.

Declared by:

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This dissertation has been submitted for examination with my approval as the candidate's advisor.

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APPROVAL PAGE

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ABSTRACT

This study assessed the existing e-learning approaches implemented in government Technical and Vocational Education and Training colleges in Ethiopia and proposed a hybrid mobile-based learning framework to address identified limitations. The study was motivated by the increasing demand for flexible digital learning environments and the persistent challenges affecting effective e-learning implementation, including poor internet connectivity, inadequate infrastructure, limited digital literacy, and insufficient support for practical skill-oriented learning. The main objectives of the study were to examine the current status of e-learning practices, identify major challenges and gaps, and propose a context-appropriate hybrid mobile learning framework suitable for Ethiopian Technical and Vocational Education and Training institutions.

A mixed research design was employed using both quantitative and qualitative approaches. Data were collected from trainers and trainees through questionnaires and interviews conducted across different government Technical and Vocational Education and Training colleges representing urban, and rural areas. Convenience Snowball Sampling. This approach was considered appropriate due to geographical dispersion, time constraints, and the online nature of the study. Quantitative data were analyzed using descriptive statistical methods, while qualitative responses were analyzed thematically.

The findings revealed that although e-learning systems were available in some institutions, their effectiveness was constrained by unreliable internet access, limited digital infrastructure, lack of training, and poor learner engagement. The study further found that mobile devices were more accessible to users than conventional computer-based systems, indicating the potential of mobile-supported learning approaches. Based on these findings, a hybrid mobile-based learning framework with offline learning capability, local data storage, and synchronization mechanisms was proposed.

The study concluded that hybrid mobile learning can improve accessibility, flexibility, and learner participation in Technical and Vocational Education and Training institutions. The study recommended improving digital infrastructure, enhancing user training, and adopting mobile-centered hybrid learning systems tailored to local educational contexts.

Keywords: e-learning, hybrid mobile learning, Technical and Vocational Education and Training, offline learning, mobile application, educational technology, Ethiopia

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full Form
DFD	Data Flow Diagram
DSR	Design Science Research
ER	Entity–Relationship
ICT	Information and Communication Technology
IT	Information Technology
MSc	Master of Science
SQL	Structured Query Language
SPSS	Statistical Package for the Social Sciences
TVET	Technical and Vocational Education and Training
API	Application Programming Interface|
FCM	Firebase Cloud Messaging

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

The great advancement, in the area of information communication and information management has made a significant transformation in various aspects of the day to day activities of modern society. The transformation can obviously be seen in several domains like transactional business, health, educational, agricultural and many other sectors. The major factor for all these changes is due to the wide utilization of computing digital devices such as computers, smartphones, tablets and laptops. These computing machines have got higher capacity in processing of data and information as they can execute substantially large number of applications on different platform.

Technical and Vocational Education and Training institutions are among the educational sectors highly influenced by digital transformation because of their strong focus on practical skill development and workforce preparation. Globally, many Technical and Vocational Education and Training institutions have begun integrating mobile learning applications, virtual laboratories, cloud-based systems, and hybrid learning models to improve practical training delivery and learner participation. Studies have shown that hybrid and mobile learning approaches can enhance competency-based education, support self-directed learning, and improve access to educational resources in low-resource environments. However, challenges such as inadequate infrastructure, internet instability, and limited digital literacy continue to affect the effectiveness of e-learning systems, particularly in developing countries (Wagino, 2026)

Recent studies emphasized that technology integration in Ethiopian Technical and Vocational Education and Training colleges remains limited due to insufficient infrastructure, weak internet access, and lack of effective digital learning strategies. Although some institutions have implemented conventional e-learning systems, many of these systems are not optimized for mobile access, offline learning, or low-bandwidth environments commonly experienced in Ethiopian contexts. (Mr. Tesfay Welamo, 2023)

Considering the widespread availability of smartphones and mobile technologies in Ethiopia, hybrid mobile-based learning approaches present a promising solution for improving accessibility, flexibility, and continuity of learning in Technical and Vocational Education

and Training institutions. Hybrid mobile learning integrates traditional face-to-face instruction with mobile-supported digital learning and offline capabilities, making it suitable for environments with limited internet connectivity. Therefore, this study focused on assessing existing e-learning approaches in Ethiopian government Technical and Vocational Education and Training colleges, identifying current gaps and challenges, and proposing a context-aware hybrid mobile-based learning framework that supports effective and accessible digital learning.

1.2 Statement of the Problem

The integration of e-learning platforms in Technical and Vocational Education and Training (TVET) colleges presents significant challenges that hinder effective teaching and learning. Despite efforts to deploy Moodle-based and other e-learning platforms in TVET Institute and its satellite colleges, issues such as limited infrastructure in rural areas, inconsistent access to digital resources, lack of awareness to use the technology and there are also other challenges that needs detail research .because of this There is a need to systematically assess current e-learning platforms and propose an improvement framework that integrates online and face-to-face learning modalities tailored to the Ethiopian TVET context.

It is believed that the communities in TVET institutions, students, instructors and other staffs are capable of utilizing mobile application for different purposes. In line with this, wireless infrastructures like Wi Fi and cellular networks are becoming common standard services in those institutions. As the devices are very much portable to the day to day activities, their usage can further be exploited in education industry. Therefore, designing a specific architecture for mobile learning application to best fit for delivering educational materials and supportive information in such institutes is crucial. In this approach, it is possible to make the traditional classroom confined offerings of learning very flexible and independent of time and location.

1.3 Research Questions

1.3.1 General Research Question

What kind of hybrid framework can be designed to address the existing challenges of e-learning in TVET colleges in Ethiopia?

1.3.2 Specific Research Questions

1. What are the prevalent e-learning platforms used in Ethiopian TVET colleges?
2. What challenges do educators and students face when utilizing these e-learning platforms?
3. How can this challenge be addressed or what solutions can be proposed?

1.4 Objectives of the Study

1.4.1 General Objective

The general objective of this study is to assess the current e-learning platforms in TVET colleges and proposing a framework to come up the drawbacks.

1.4.2 Specific Objectives

In order to achieve the intended objective in this study, there will be several specific activities to be performed sequentially.

- To assess the current state of e-learning platforms in TVET colleges.
- To identify the challenges and barriers faced by educators and students in using these platforms.
- To propose a hybrid architecture framework that integrates traditional teaching methods with e-learning technologies tailored to the Ethiopian context.

1.5 Significance of the Study

The significance of this study lies in several key contributions:

It addresses the critical need to evaluate and enhance the readiness and effectiveness of e-learning platforms in Technical and Vocational Education and Training (TVET) colleges, which currently face challenges such as limited ICT infrastructure, low digital literacy among teachers, and inadequate integration of digital tools in teaching.

By proposing a hybrid architecture framework, the study aims to provide a tailored, solution that can improve the functionality, accessibility, and sustainability of e-learning systems in these institutions, thereby supporting more interactive, flexible, and technology-aligned learning experiences.

The research contributes to improving teaching methodologies and learning outcomes in TVET colleges by identifying barriers to digital adoption and recommending strategies for better integration of e-learning technologies, which is crucial for aligning education with the demands of a technology-driven labour market and enhancing graduate employability.

In summary, this study is significant because it not only assesses current e-learning conditions in Ethiopian TVET colleges but also proposes a hybrid framework that can enhance digital learning environments, improve educational quality, student engagement and contribute to broader socio-economic development goals in Ethiopia.

1.6 Scope of the Study

This study focused on assessing existing e-learning approaches and designing a context-aware hybrid mobile learning framework for government Technical and Vocational Education and Training colleges in Ethiopia. Geographically, the study was limited to government TVET colleges located in urban, semi-urban, and rural areas of Ethiopia in order to capture variations in technological infrastructure, internet accessibility, and digital learning practices across different environments. The study primarily targeted trainers, trainees, and selected ICT professionals involved in the implementation and management of e-learning systems within the selected institutions.

1.7 Limitations of the Study

This study had some limitations that may affect the generalizability and implementation scope of the findings. First, the study was limited to government Technical and Vocational Education and Training colleges in Ethiopia and did not include private TVET institutions or universities. Therefore, the findings may not fully represent all educational institutions implementing e-learning systems across the country.

Second, the study focused primarily on assessing e-learning practices and proposing a contextual hybrid mobile learning framework rather than developing and deploying a fully functional software system. As a result, the actual technical performance, scalability, and operational effectiveness of the proposed framework were not tested through real-world implementation and experimental evaluation.

Third, the study relied mainly on data collected through questionnaires and interviews from trainers, trainees, and ICT professionals. Since the responses were based on participants' experiences and perceptions, there was a possibility of response bias, misunderstanding of questions, or inaccurate self-reporting. In addition, some participants may have had limited technical knowledge regarding advanced e-learning technologies and mobile learning systems.

Another limitation was related to time, budget, and geographical accessibility constraints. Due to limited resources, the study could not include a larger number of TVET colleges from all regions of Ethiopia. Some remote institutions with severe infrastructure limitations were difficult to access during the data collection process. Consequently, the sample size and institutional coverage were restricted to manageable locations and participants.

The study also concentrated mainly on mobile-supported hybrid learning and offline accessibility challenges within low-resource environments. Other important dimensions such as cybersecurity, advanced artificial intelligence integration, virtual laboratories, and large-scale cloud deployment architectures were beyond the scope of this research.

Finally, the rapidly evolving nature of information and communication technologies may affect the long-term applicability of some technological assumptions and framework components proposed in the study. Therefore, future studies may be required to validate,

implement, and enhance the framework using emerging technologies and broader institutional contexts.

1.8 Organization of the Dissertation

This dissertation is organized into five chapters. Chapter One presents the background, problem statement, research questions, objectives, significance, scope, and limitations of the study. Chapter Two reviews the theoretical, conceptual, and empirical literature and identifies the research gap. Chapter Three describes the research methodology, including research design, study area, population and sampling, data sources, data collection methods, system development methodology, tools and technologies, data analysis methods, ethical considerations, and validity and reliability. Chapter Four presents the system analysis, design, implementation, testing, and results, along with their discussion. Chapter Five concludes the dissertation by summarizing the major findings, drawing conclusions, presenting contributions, and offering recommendations and directions for future work. The dissertation ends with references and appendices.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter presents a review of related literature relevant to the assessment of e-learning practices and the design of a context-aware hybrid mobile learning framework for government TVET colleges in Ethiopia. The purpose of the literature review is to examine existing studies, theories, models, technologies, and research findings related to e-learning systems, hybrid learning, mobile learning, and educational technology adoption in Technical and Vocational Education and Training environments. The chapter also identifies existing research gaps, technological limitations, and contextual challenges associated with the implementation of e-learning systems in low-resource educational settings. Furthermore, the review provides the theoretical and conceptual foundation for the proposed hybrid mobile learning framework.

To conduct the literature review, various academic databases and digital libraries were systematically searched to identify relevant scholarly materials. The major sources included research gate ,IEEE Xplore and Google Scholar. The search process used keywords and phrases such as “e-learning in TVET,” “hybrid mobile learning,” “mobile learning systems,” “offline learning applications,” “blended learning in developing countries,” “educational technology adoption,” “mobile learning framework,” and “digital learning in Ethiopia.” Priority was given to peer-reviewed journal articles, conference papers, institutional reports, and recent scholarly publications. The review mainly considered studies published between 2020 and 2025 to ensure the inclusion of recent technological developments and current educational trends. However, some foundational theories and highly relevant earlier studies were also included where necessary.

2.2 Theoretical Review

This study was grounded on theories and models related to technology adoption, mobile learning, and blended learning environments. The selected theories provided conceptual foundations for understanding user acceptance of e-learning technologies, the integration of mobile-supported learning systems, and the design of a hybrid learning framework suitable

for government TVET colleges in Ethiopia. The study particularly adopted the Technology Acceptance Model, Mobile Learning Theory, and Blended Learning Theory because of their relevance to educational technology adoption and hybrid mobile learning environments.

Technology Acceptance Model

The Technology Acceptance Model was developed by Davis in 1989 to explain how users accept and use information systems and technologies. The model proposes that user adoption of a technological system is primarily influenced by two key constructs: perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which users believe that using a system improves their performance or productivity, while perceived ease of use refers to the degree to which users believe that the system is simple and effortless to use.

The Technology Acceptance Model has been widely applied in studies related to e-learning, mobile learning, information systems, and educational technology adoption because it helps explain users' behavioral intentions toward technology usage. In the context of this study, trainers and trainees in government TVET colleges are more likely to adopt a hybrid mobile learning system if they perceive the system as useful, accessible, and easy to operate within their learning environments. The model is appropriate for this study because the proposed framework aims to improve accessibility, usability, flexibility, and user engagement in low-resource educational settings. The Technology Acceptance Model therefore provides a strong theoretical foundation for analyzing user readiness, technology acceptance, and adoption challenges associated with hybrid mobile learning systems. (Liu, 2025)

Mobile Learning Theory

Mobile Learning Theory explains how mobile technologies support learning beyond traditional classroom environments by enabling learners to access educational resources anytime and anywhere through portable digital devices. The theory emphasizes flexibility, accessibility, portability, learner-centered interaction, and continuous learning supported by mobile technologies such as smartphones and tablets. Mobile learning supports formal and informal learning experiences by allowing learners to engage with educational content regardless of geographical and time limitations.

This theory is highly relevant to the present study because mobile devices are more accessible to many trainees and trainers in Ethiopian TVET colleges compared to desktop computers and conventional computer laboratories. The proposed hybrid framework relies heavily on mobile-supported learning and offline accessibility to address challenges related to poor internet connectivity and limited infrastructure. Mobile Learning Theory supports the idea that educational systems should be designed to provide flexible and context-aware access to learning materials through mobile technologies. Therefore, the theory provides a conceptual basis for integrating mobile-first learning approaches into the proposed hybrid framework.

Blended Learning Theory

Blended Learning Theory focuses on the integration of traditional face-to-face instruction with digital and online learning approaches to create a flexible and interactive learning environment. The theory emphasizes that combining physical classroom instruction with technology-supported learning can improve learner participation, collaboration, flexibility, and educational effectiveness. Blended learning environments allow learners to benefit from both direct instructor interaction and independent digital learning experiences.

The relevance of Blended Learning Theory to this study lies in the hybrid nature of the proposed framework. The framework combines conventional classroom-based TVET instruction with mobile-supported digital learning and offline educational resources. Since Technical and Vocational Education and Training institutions require practical and competency-based learning activities, a fully online learning environment may not adequately support all instructional requirements. Therefore, integrating face-to-face instruction with mobile-supported learning provides a more suitable educational approach for the Ethiopian TVET context. The theory also supports the framework's objective of enhancing learning continuity, accessibility, and flexibility while maintaining practical instructional interaction.

no	Theory	Role in the research
1	Technology Acceptance Model	Technology adoption
2	Mobile Learning Theory	Mobile accessibility
3	Blended Learning Theory	Hybrid instruction

Table 1 Theoretical Review summary

2.3 Conceptual Review

This section presents the major concepts, variables, and technical terms related to the study. The conceptual review provides operational definitions and explains how each concept is applied within the context of assessing e-learning practices and designing a context-aware hybrid mobile learning framework for government TVET colleges in Ethiopia.

E-Learning

E-learning refers to the use of information and communication technologies to facilitate teaching and learning processes through electronic platforms, digital resources, and internet-based systems. According to UNESCO, e-learning enables learners to access educational content electronically through computers, mobile devices, and online platforms regardless of geographical location. E-learning systems commonly include learning management systems, virtual classrooms, online assessments, multimedia resources, and collaborative communication tools.

In this study, e-learning refers to the existing digital learning approaches implemented within government TVET colleges in Ethiopia. The concept is operationalized through variables such as accessibility, usability, internet dependency, learner engagement, digital infrastructure availability, and effectiveness of current learning platforms. (Yasmin Bibi, 2024)

Mobile Learning

Mobile learning refers to educational activities conducted through portable digital devices such as smartphones, tablets, and handheld wireless technologies. Mobile learning enables learners to access educational resources anytime and anywhere through mobile-supported platforms. Recent studies emphasize that mobile learning supports flexible, learner-centered, and context-aware educational experiences beyond traditional classroom environments.

This concept is highly relevant to the study because many trainees and trainers in Ethiopian TVET colleges rely more on smartphones than desktop computers for accessing educational content. In this study, mobile learning is operationalized through mobile accessibility, device compatibility, portability, learner flexibility, and continuous access to learning materials. (Kyslova, 2025)

Hybrid Learning

Hybrid learning, also referred to as blended learning, combines traditional face-to-face instruction with online or technology-supported learning approaches. Hybrid learning environments integrate classroom interaction with digital educational tools to improve flexibility, accessibility, learner engagement, and instructional continuity. Recent literature indicates that hybrid learning has become an effective educational approach for supporting flexible and student-centered learning environments.

In the context of this study, hybrid learning refers to the integration of classroom-based TVET instruction with mobile-supported digital learning environments capable of operating both online and offline. The concept is operationalized through blended instructional delivery, digital resource integration, mobile-supported learning, learner participation, and flexible educational accessibility. (Dorsah, 2025)

Offline Learning Capability

Offline learning capability refers to the ability of a learning system to provide educational services and access to learning resources without requiring continuous internet connectivity. Offline-capable systems use local storage, temporary databases, caching mechanisms, and synchronization technologies to maintain learning continuity in low-connectivity environments some applications and Systems with Offline Learning Capability include Moodle Mobile App and Kolibri.

This concept is highly important in the Ethiopian TVET context where internet connectivity is often unstable or unavailable in rural and semi-urban areas. In this study, offline learning capability is operationalized through local data storage, offline access to educational resources, synchronization support, local caching, and delayed cloud synchronization when internet access becomes available

Context-Aware Hybrid Mobile Learning Framework

A context-aware hybrid mobile learning framework refers to a structured educational technology model designed to adapt to users' environmental, technological, and infrastructural conditions while integrating mobile learning and blended instructional approaches. Context-aware systems consider factors such as connectivity limitations, device

availability, infrastructure conditions, learner behavior, and user accessibility during system design and implementation.

In this study, the proposed framework represents the primary research contribution intended to address existing e-learning challenges in Ethiopian government TVET colleges. The framework is operationalized through mobile accessibility, offline-first architecture, synchronization mechanisms, cloud integration, learner interaction, and adaptability to low-resource educational environments. (Sahara, 2025)

The reviewed concepts provide the conceptual foundation for understanding the technological, pedagogical, and operational dimensions of the study. The concepts of e-learning, mobile learning, hybrid learning, offline learning capability, learning management systems, and context-aware framework design collectively support the assessment of existing digital learning challenges and the development of an appropriate hybrid mobile learning framework for Ethiopian government TVET colleges. The reviewed concepts also guide the identification of system requirements, framework components, and evaluation criteria used throughout the research process.

2.4 Empirical Review

This section critically reviews recent empirical studies related to e-learning systems, hybrid mobile learning, offline learning technologies, mobile learning adoption, and ICT-supported education in developing countries and TVET institutions. The studies are grouped thematically to identify existing knowledge, research gaps, and limitations relevant to the current study.

Empirical Study1 Siddiqullah Barikzai, Vijayakumar Bharathi S, and Arif Perdana (2024) conducted a study entitled *"Challenges and Strategies in E-Learning Adoption in Emerging Economies"* to investigate the major barriers affecting e-learning implementation in developing countries. The study focuses on Challenges and strategies in e-learning adoption the paper provides a comprehensive examination of the factors influencing e-learning implementation in these contexts, synthesizing findings from 84 studies to identify critical success and failure factors, as well as actionable strategies and research gaps

The study employed a systematic literature review methodology by analyzing previous empirical studies related to e-learning adoption, ICT infrastructure, digital literacy, institutional readiness, and online learning implementation in developing countries.

The researcher's synthesized evidence from multiple studies conducted across emerging economies, including countries affected by limited internet infrastructure and resource constraints. Most failure factors that are found from the data analysis are Low ICT knowledge, Poor technology skills and resistance to change, Poor infrastructure, Lack of expertise in e-learning and low awareness. And the recommended solution that is mentioned is invest in infrastructure, training and capitalize on mobile technology .

The findings revealed that several critical factors significantly affect successful e-learning implementation. These included unstable electricity supply, inadequate internet bandwidth, poor ICT infrastructure, insufficient digital literacy, language barriers, limited institutional funding, weak policy implementation, and resistance to technological change. The study also emphasized that the COVID-19 pandemic exposed major weaknesses in educational systems, especially in developing countries where institutions lacked adequate technological preparedness for online learning environments.

However, the study had several limitations. First, the research mainly focused on general e-learning adoption challenges rather than specifically addressing Technical and Vocational Education and Training (TVET) institutions. Second, the study did not propose a concrete technical framework or system architecture capable of supporting offline learning, synchronization, or hybrid mobile learning approaches. (Siddiqullah Barikzaia, 2024)

Empirical Study 2 Mohamad Ahmad Saleem Khasawneh et al. (2023) conducted a study entitled *"Analyzing the Effectiveness of Mobile Devices and Apps in Supporting Learning"* to investigate the impact of mobile learning applications on students' academic performance and engagement. The study employed a quantitative research methodology using surveys, correlation analysis, and pre-test/post-test evaluation techniques. The research was conducted among high school students in Jordan to assess perceptions of mobile learning and its educational effectiveness.

The findings indicated after the implementation of mobile application the result of students increased compared to the result scored before. Additionally, the study found that learners showed positive attitudes toward mobile learning and self-directed learning environments.

Educators also perceived mobile learning as beneficial for personalized and flexible instruction.

However, the study mainly evaluated mobile learning effectiveness without addressing infrastructural challenges such as poor internet connectivity, offline learning capability, synchronization mechanisms, or hybrid mobile learning architectures. Furthermore, the study was conducted in the Jordanian educational context, which differs from the infrastructural and socio-economic realities of Ethiopian government TVET colleges. (Khasawneh1, 2023)

Empirical study 3 Joseph Mesuwini and Sello Mokoena (2024) explored the challenges experienced by TVET lecturers during the transition from traditional teaching to online learning in South African TVET institutions. The objective of the study was to investigate barriers affecting online teaching and learning implementation in vocational education environments. The researchers employed an interview-based qualitative research methodology involving lecturers in TVET colleges.

The findings revealed that inadequate technology infrastructure, unstable internet connectivity, unreliable electricity supply, and limited computer literacy among both lecturers and students significantly affected online learning effectiveness. The study further emphasized that educational inequalities increased because many learners lacked access to digital devices and affordable internet services.

However, the study recommend overall TVET policy update but it did not propose a concrete technological framework for improving learning systems. Furthermore, offline learning mechanisms and synchronization technologies were not addressed.

The study is relevant to the current research because it demonstrates the infrastructural and technological challenges affecting TVET institutions in African contexts. Unlike the current study, however, it does not design or evaluate a hybrid mobile learning framework tailored for low-connectivity environments. (Mesuwini1≅, 2024)

Empirical Study 4 : (2020) conducted a study in maynamar to examine factors affecting e-learning adoption in technical and vocational institutions. The study used a quantitative research design with questionnaire data collected from 210 students and instructors. The findings revealed that poor internet connectivity, limited ICT infrastructure, and low digital literacy significantly affected e-learning implementation. The study recommended mobile-supported learning approaches. However, the research mainly focused on general e-learning adoption and did not propose an offline-capable mobile framework. (Khaing, 2020)

Empirical study 5 Moris Zahtila and Dirk Burghardt (2022) conducted a study entitled *"Location-Based Mobile Learning on Relief Mapping Methods"* to investigate the effectiveness of location-based mobile learning (LBML) in supporting cartography education through contextual outdoor learning activities. The objective of the study was to develop and evaluate a mobile learning application that enhances students' understanding of relief representation methods in cartography using real-world field exercises and gamified learning approaches.

The researchers employed an experimental and application-based research methodology. A quiz-based mobile application called *mCartoLearn* was designed and implemented for Android devices. The study integrated collaborative learning, gamification, user experience theory, and contextual learning principles within outdoor educational activities. The experiment involved two groups of university cartography students during field learning exercises conducted in different learning environments.

The findings revealed that location-based mobile learning significantly improved students' engagement, motivation, and understanding of cartographic relief representation methods. Students participating in outdoor contextual learning activities demonstrated better knowledge improvement and stronger real-world understanding compared to traditional indoor learning approaches. The study further showed that mobile learning applications enhance learner interaction, collaborative learning, and practical knowledge acquisition. Additionally, learners positively evaluated the usability and user experience of the mobile application.

However, the study focused specifically on cartography education rather than Technical and Vocational Education and Training (TVET) institutions. Second, the study did not address broader educational management functionalities such as assignment submission, offline synchronization, communication systems, or hybrid learning integration.

The study is relevant to the current research because it demonstrates the effectiveness of mobile learning applications in improving learner engagement, practical understanding, and contextualized education. The integration of collaborative learning, gamification, and mobile-based educational support aligns with the objectives of the current study. (Cartog, 2022)

Empirical study 6 Alina Shamsuddin, Eta Wahab, Nor Hazana Abdullah, and Azeanita Suratkon (2018) conducted a study entitled *"Mobile Learning Adoption in Enhancing Learning Experience among HEI Students"* to investigate the factors influencing mobile

learning adoption and to determine the level of mobile learning utilization among Higher Education Institution (HEI) students in Malaysia. The study aimed to evaluate how mobile learning technologies enhance students' learning experiences within higher education environments.

The researchers employed a quantitative research methodology using survey questionnaires distributed to undergraduate students from eight different faculties in a Malaysian public university. The study involved a sample of 369 students, and the collected data were analyzed using the Statistical Package for Social Sciences (SPSS) version 22. Additionally, the study applied STEEPV analysis (Social, Technological, Economic, Environmental, Political, and Values analysis) to identify the major factors influencing mobile learning adoption.

The findings revealed that technological factors were the most significant determinants influencing mobile learning adoption among university students. The study further showed that the overall level of mobile learning adoption among students was high, indicating positive acceptance and readiness toward mobile-supported education. The researchers found that mobile learning enhanced students' flexibility, accessibility, and learning experiences by enabling educational access through smartphones and mobile devices. However, despite the positive adoption level, internet coverage and connection speed were identified as the major barriers affecting effective mobile learning implementation. (Alina Shamsuddin, 2018)

Empirical study 7 Afang Li, Norhasmah Mohd Zain, and colleagues (2025) conducted a study entitled *"Effectiveness of Online and Offline Blended Teaching Methods Using a Mobile Application on Surgical Nursing Apprenticeship"* to evaluate the effectiveness of a hybrid online-offline mobile learning application in improving nursing apprenticeship education. The objective of the study was to compare blended mobile learning approaches with traditional face-to-face teaching methods in nursing education. The researchers employed a clustered randomized controlled trial methodology involving 166 nursing students divided into intervention and control groups. The intervention group used the "Learning Pass" mobile application integrated with online and offline learning activities.

The findings revealed that students who used the hybrid mobile learning application demonstrated significantly better learning outcomes, improved practical skills, and higher learner satisfaction compared to students receiving traditional instruction. The study also showed that combining online and offline learning through mobile applications enhanced learning flexibility, accessibility, and continuous learner engagement.

However, the study focused specifically on nursing apprenticeship education rather than Technical and Vocational Education and Training (TVET) institutions. In addition, the study was conducted within relatively stable technological environments and did not fully address infrastructural limitations such as poor connectivity, limited ICT resources, and multilingual educational contexts commonly experienced in Ethiopian government TVET colleges.

The study is relevant to the current research because it demonstrates the effectiveness of hybrid mobile learning applications in improving learner engagement and educational performance. Nevertheless, unlike the current study, it does not propose a context-aware hybrid mobile learning framework tailored for low-connectivity TVET environments. (Afang Li, 2025)

Empirical study 8 Etsegent Arega Asmamaw and colleagues (2025) conducted a study entitled *"Empowering Community Health Workers in Rural Ethiopia with Blended Learning: An Offline Mobile Application to Enhance Trainings and Healthcare Services"* to investigate the effectiveness of an offline multilingual mobile learning application in improving blended learning among community health workers in rural Ethiopia. The objective of the study was to evaluate whether offline-capable blended learning applications could improve training accessibility and educational outcomes in low-resource environments. The researchers employed a mixed-methods quasi-experimental research design involving health extension workers from 40 districts in Ethiopia.

The findings indicated that the offline mobile learning application significantly improved learner knowledge, accessibility, training flexibility, and learner satisfaction compared to traditional training approaches. The study further demonstrated that offline-first mobile learning systems are effective in low-connectivity and resource-constrained educational environments. The multilingual support integrated within the application also improved accessibility and user adoption.

However, the study focused primarily on healthcare training rather than TVET education. Furthermore, the research mainly evaluated training effectiveness without proposing a complete hybrid mobile learning framework integrating institutional learning management services, assessment systems, communication modules, and synchronization architectures for vocational education institutions.

The study is highly relevant to the current research because it empirically demonstrates the effectiveness of offline mobile learning applications in Ethiopian low-connectivity contexts.

Unlike the current study, however, it does not specifically address Ethiopian government TVET colleges or competency-based vocational learning systems.

Empirical study 9 Guoyu Xue (2025) conducted a study entitled *"Construction of a Hybrid Learning Model Based on Mobile Interaction Technology in Vocational Schools and its Mechanism for the Quality Assurance of Teaching"* to explore the development of hybrid learning models supported by mobile interaction technologies in vocational education institutions. The objective of the study was to investigate how mobile-supported hybrid learning environments improve instructional quality and learner interaction in vocational schools. The study employed analytical and model-construction research approaches focusing on mobile interaction technologies and implicit learner interaction analysis within vocational education environments.

The findings revealed that hybrid mobile learning environments improved learner interaction, flexibility, instructional quality, and collaborative learning experiences. The study also showed that mobile interaction technologies enhanced real-time communication and learner engagement within hybrid learning environments. Furthermore, the research highlighted the importance of integrating online and offline learning resources in vocational education systems.

However, the study mainly focused on interaction modeling and instructional quality assurance rather than offline synchronization, local mobile storage, or low-bandwidth educational environments. Additionally, the study was conducted in technologically advanced educational settings that differ significantly from the infrastructural limitations of Ethiopian government TVET colleges. (Xue, 2025)

The study is relevant to the current research because it supports the integration of mobile interaction technologies within hybrid vocational learning systems. Nevertheless, unlike the present study, it does not propose an offline-first, context-aware hybrid mobile learning framework specifically designed for Ethiopian TVET institutions operating in low-connectivity environments.

Empirical study 10 Mona Masrom et al. (2022) conducted a study entitled *"Hybrid Mobile Learning Application for Technical Education"* to investigate the effectiveness of hybrid mobile learning applications in supporting technical and vocational education students. The objective of the study was to evaluate how mobile-supported hybrid learning environments improve learner engagement, accessibility, and flexible learning experiences among technical

education students. The researchers employed a quantitative survey-based research methodology involving university and technical college students using mobile learning platforms.

The findings revealed that hybrid mobile learning applications improved learner participation, learning flexibility, and educational accessibility. Students reported positive perceptions regarding mobile accessibility, self-paced learning, and continuous educational interaction beyond classroom environments. The study further emphasized that mobile learning systems support blended learning implementation by integrating classroom learning with online educational services.

However, the study focused mainly on learner perception and acceptance without addressing offline synchronization mechanisms, local storage technologies, or low-connectivity learning environments. Furthermore, the research did not specifically address Ethiopian TVET institutions or infrastructural limitations affecting developing countries. (Kamaludin2, 2022)

The study is relevant to the current research because it demonstrates the educational benefits of hybrid mobile learning systems within technical education environments. Nevertheless, unlike the current study, it does not propose an offline-first hybrid mobile framework tailored for Ethiopian government TVET colleges.

The reviewed empirical studies demonstrate that mobile learning, blended learning, and hybrid learning systems significantly improve learner engagement, accessibility, flexibility, collaboration, and academic performance across different educational environments. Most studies reported that mobile-supported learning environments enhance self-directed learning, continuous educational access, learner participation, and communication between instructors and students. The findings also revealed that hybrid learning approaches combining face-to-face instruction with mobile or online learning provide better educational continuity and flexibility compared to traditional learning methods.

Several studies further identified the growing importance of mobile learning technologies due to increased smartphone accessibility among students. Research conducted in higher education institutions and vocational learning environments showed that learners generally demonstrate positive attitudes toward mobile learning applications because of their convenience, portability, and ease of access to educational resources. In addition, studies involving offline and blended mobile learning systems indicated that offline-capable

applications improve learning continuity in low-connectivity and resource-constrained environments.

Despite these positive findings, the reviewed studies consistently identified major challenges affecting successful e-learning and mobile learning implementation, particularly in developing countries. These challenges include unstable internet connectivity, inadequate ICT infrastructure, limited digital literacy, insufficient institutional support, unreliable electricity supply, and lack of mobile-optimized learning systems. Furthermore, learners in rural and underserved areas were disproportionately affected by poor network accessibility and limited technological resources.

The review also revealed several important research gaps. Most existing studies focused primarily on general e-learning adoption, learner acceptance, or educational effectiveness without proposing comprehensive hybrid mobile learning frameworks capable of supporting offline learning, synchronization mechanisms, local storage systems, multilingual support, and low-bandwidth optimization. Additionally, limited empirical studies specifically addressed Technical and Vocational Education and Training (TVET) institutions, particularly within the Ethiopian educational context.

Therefore, the current study seeks to address these identified gaps by proposing and evaluating a context-aware hybrid mobile learning framework designed specifically for Ethiopian government TVET colleges. The proposed framework integrates mobile-first and offline-first learning approaches, local storage technologies, REST API synchronization, and hybrid learning principles to improve accessibility, flexibility, and learning continuity in low-connectivity educational environments.

2.5 Research Gap

The reviewed literature indicates that mobile learning, blended learning, and hybrid learning systems have significantly improved learner engagement, accessibility, flexibility, and educational continuity in various educational environments. Previous empirical studies demonstrated the positive impact of mobile learning technologies on academic performance, learner participation, and self-directed learning. In addition, several studies identified the importance of integrating online and offline learning approaches to address accessibility challenges in low-resource educational settings.

However, despite these contributions, several important gaps remain unresolved. First, most existing studies focused primarily on general higher education institutions rather than Technical and Vocational Education and Training (TVET) colleges. Very limited empirical research has specifically examined hybrid mobile learning systems within government TVET institutions, particularly in developing countries such as Ethiopia.

Second, many previous studies mainly concentrated on learner acceptance, adoption factors, or educational outcomes without proposing comprehensive technical frameworks capable of supporting offline learning functionality, synchronization mechanisms, local mobile storage, multilingual support, and low-bandwidth optimization. Existing mobile learning applications often depend heavily on stable internet connectivity, which remains a major challenge in Ethiopian educational environments, especially in semi-urban and rural areas.

Third, although some studies discussed blended and mobile learning environments, limited research has integrated mobile-first and offline-first architectural approaches within competency-based TVET education systems. Furthermore, few studies have incorporated technical components such as SQLite local databases, REST API synchronization, cloud backend services, notification systems, and hybrid mobile application architectures suitable for low-connectivity vocational learning environments.

Methodologically, most previous studies focused on evaluating existing systems rather than proposing and validating context-aware frameworks through feedback from trainees, trainers, and ICT professionals. In addition, there is limited empirical evidence regarding the applicability and effectiveness of hybrid mobile learning frameworks tailored specifically for Ethiopian government TVET colleges.

Therefore, this study seeks to fill these identified gaps by proposing and evaluating a context-aware hybrid mobile learning framework designed specifically for Ethiopian government TVET colleges. The proposed framework integrates offline-first mobile learning, synchronization mechanisms, local storage technologies, multilingual support, and hybrid learning principles to improve accessibility, flexibility, and learning continuity in low-connectivity educational environments.

2.6 Conceptual Framework

The conceptual framework of this study illustrates the relationship between the existing e-learning challenges in Ethiopian government TVET colleges, the proposed hybrid mobile learning framework, and the expected educational outcomes. The framework was developed based on the reviewed literature, identified research gaps, and the technological requirements of low-connectivity vocational learning environments.

The framework assumes that several infrastructural, technological, and educational factors negatively affect the effectiveness of existing e-learning systems in Ethiopian government TVET colleges. These factors include unstable internet connectivity, inadequate ICT infrastructure, limited accessibility of learning resources, lack of offline learning support, low mobile optimization, insufficient learner engagement, and limited flexibility in accessing educational materials.

To address these challenges, the study proposes a context-aware hybrid mobile learning framework integrating mobile-first and offline-first learning approaches. The framework combines mobile application technologies, local mobile storage, cloud backend services, REST API communication, synchronization mechanisms, and hybrid learning principles to support both online and offline educational activities.

The proposed framework consists of several major components, including the mobile application layer, local SQLite database, application server/cloud backend, central database system, synchronization services, notification, learning management services, and multilingual support mechanisms. The framework allows trainees and trainers to access learning materials, assignments, quizzes, notifications, and communication services through smartphones even in low-connectivity environments.

The framework further assumes that integrating offline learning capability, synchronization services, and mobile accessibility will improve learner engagement, flexibility, educational accessibility, and learning continuity within Ethiopian TVET institutions.

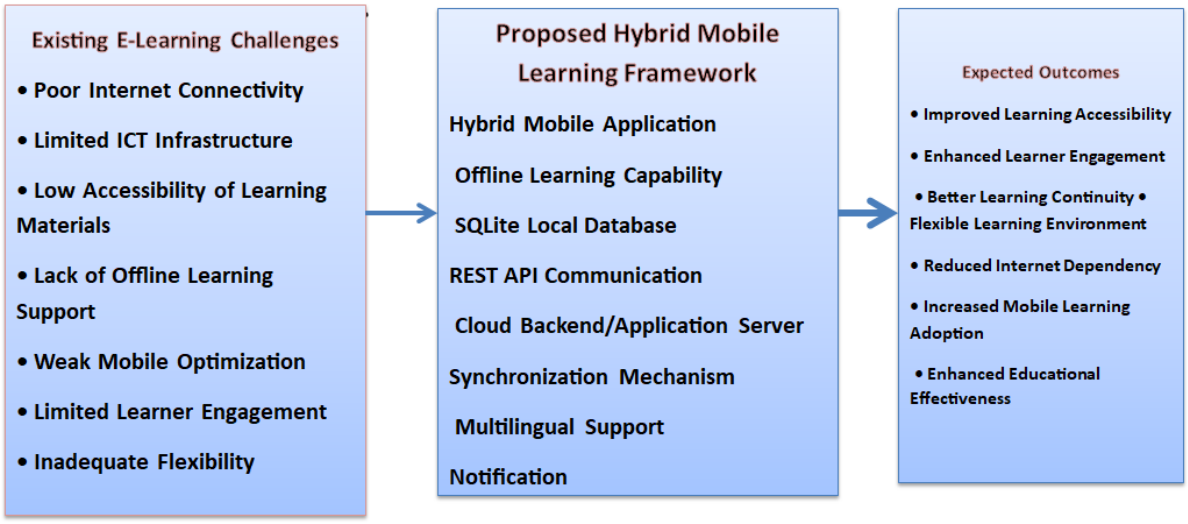


Figure 1 *Conceptual Framework of the Study (Source: reviewed literature and collected data Author: the researcher, 2026)*

2.7 Summary of Literature Review

The literature review examined theoretical, conceptual, and empirical studies related to e-learning systems, mobile learning, hybrid learning environments, and educational technology adoption. The theoretical review highlighted the relevance of the Technology Acceptance Model (TAM), Constructivist Learning Theory, and Mobile Learning Theory in explaining learner acceptance, interactive learning, flexibility, and mobile-supported educational environments. These theories collectively emphasize the importance of usability, learner-centered instruction, accessibility, and technology-supported collaborative learning within modern educational systems.

The conceptual review discussed key concepts related to hybrid mobile learning systems, including mobile learning applications, offline learning capability, REST API communication, synchronization mechanisms, local mobile databases, cloud backend services, and hybrid learning environments. The review demonstrated that integrating offline-first and mobile-first learning approaches can improve educational accessibility and continuity, particularly in low-connectivity environments. Furthermore, the conceptual framework illustrated how the proposed hybrid mobile learning framework addresses existing infrastructural and technological challenges affecting e-learning implementation in Ethiopian government TVET colleges.

The empirical review analyzed recent studies related to e-learning adoption, mobile learning systems, blended learning environments, hybrid mobile learning applications, and ICT-

supported education in developing countries. The reviewed studies consistently indicated that mobile and hybrid learning systems improve learner engagement, flexibility, educational accessibility, and learning continuity. However, the literature also identified several persistent challenges, including unstable internet connectivity, inadequate ICT infrastructure, limited offline learning support, low digital literacy, and insufficient mobile optimization, particularly within developing countries and vocational education environments.

Despite the growing body of research on mobile and blended learning systems, important gaps remain unresolved. Most existing studies focused primarily on general higher education institutions rather than Technical and Vocational Education and Training (TVET) colleges. Additionally, limited studies proposed context-aware hybrid mobile learning frameworks capable of supporting offline learning, synchronization mechanisms, local storage systems, multilingual support, and low-bandwidth optimization suitable for Ethiopian government TVET colleges. Therefore, the current study seeks to address these gaps by proposing and evaluating a context-aware hybrid mobile learning framework designed to improve accessibility, flexibility, and learning continuity within low-connectivity TVET educational environments.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter highlights the research design and approach, population, sample size and sampling techniques, the data collection tools, validity and reliability, method of data analysis and the ethical considerations. In addition to that it consists of the justification for choosing the approaches. It also describes how these methods will be implemented to find answers for the purpose of the study.

3.2 Research Design

This study employed a Design Science Research (DSR) approach integrated with qualitative and quantitative research methods to design and evaluate a hybrid mobile learning framework for Ethiopian government TVET colleges. Design Science Research was selected because the primary objective of the study is to propose a practical technological solution capable of addressing existing e-learning challenges in low-connectivity vocational educational environments. The study focuses on the development and evaluation of a context-aware hybrid mobile learning framework rather than only examining theoretical relationships among variables.

Design Science Research is widely used in Information Technology, Information Systems, Software Engineering, and Computer Science studies involving the development of software systems, frameworks, models, and technological artifacts. The DSR approach supports problem identification, artifact design, framework development, evaluation, and iterative improvement. In the context of this research, the proposed hybrid mobile learning framework represents the main technological artifact designed to improve educational accessibility, flexibility, learner engagement, and learning continuity within Ethiopian government TVET colleges.

The study also incorporated mixed research methods to collect comprehensive data from trainees, trainers, and ICT professionals. Quantitative methods were employed to gather structured responses regarding existing e-learning challenges, mobile learning accessibility, internet connectivity issues, and user perceptions toward hybrid mobile learning systems.

Qualitative methods were used to collect expert opinions, recommendations, and professional evaluations regarding the effectiveness, feasibility, and applicability of the proposed framework.

The research process followed several major phases. First, existing e-learning challenges and institutional requirements were identified through literature review, questionnaires, interviews, and preliminary observations conducted within selected government TVET colleges. Second, theoretical and empirical literature related to mobile learning, hybrid learning, offline learning systems, and educational technology adoption were reviewed to establish the conceptual and technical foundations of the study. Third, a context-aware hybrid mobile learning framework was designed by integrating mobile-first and offline-first architectural principles, local storage mechanisms, synchronization services, REST API communication, and cloud backend technologies.

Finally, the proposed framework was evaluated through feedback collected from ICT professionals, trainers, and educational stakeholders to assess its usability, practicality, effectiveness, and suitability for low-connectivity TVET learning environments. The evaluation process focused on determining whether the proposed framework adequately addresses the identified e-learning challenges affecting Ethiopian government TVET colleges.

The Design Science Research approach was considered appropriate for this study because it provides a systematic methodology for developing, validating, and evaluating technological solutions aimed at solving real-world educational and infrastructural problems within Information Technology and vocational education contexts.

3.3 Study Area

The study was conducted in selected Ethiopian government Technical and Vocational Education and Training (TVET) colleges. These institutions operate under the Ethiopian TVET system, which aims to develop skilled human resources through competency-based technical and vocational education. The study particularly focused on government TVET colleges located in urban, semi-urban, and rural areas to assess differences in technological infrastructure, internet accessibility, and e-learning implementation challenges.

Government TVET colleges were selected because they are increasingly adopting digital learning systems and educational technologies; however, many institutions continue to face significant challenges related to unstable internet connectivity, inadequate ICT infrastructure, limited mobile learning support, and insufficient access to online educational resources. These challenges directly affect the effectiveness of existing e-learning systems and learning continuity among trainees and trainers.

The selected TVET colleges are relevant to the study because they represent real educational environments where hybrid mobile learning systems could improve accessibility, flexibility, learner engagement, and educational continuity, particularly within low-connectivity settings. In addition, the institutions provide appropriate contexts for evaluating the applicability and effectiveness of the proposed hybrid mobile learning framework within Ethiopian vocational education environments.

3.4 Population and Sampling Technique

The target population of this study consisted of trainees, trainers, and ICT professionals of Ethiopian government Technical and Vocational Education and Training (TVET) colleges. These participants were selected because they are directly involved in the use, management, and implementation of e-learning and mobile learning systems within TVET institutions.

Due to the absence of a centralized population database and the geographically distributed nature of Ethiopian government TVET colleges, the study employed non-probability sampling techniques, specifically convenience sampling and snowball sampling. Initial participants were selected based on accessibility and institutional connections, and

respondents were further requested to distribute the questionnaire to colleagues, co-workers, and trainees within their institutions.

The sample size for the study was determined based on Roscoe's (1975) rule of thumb, which suggests that sample sizes between 30 and 500 are generally appropriate for most behavioral, educational, and social science research studies. Since the study aimed to gather diverse perspectives from trainees, trainers, and ICT professionals across multiple TVET institutions, a sample size of approximately 100–200 participants was considered adequate for achieving meaningful analysis and framework evaluation.

Target Group	Population (N)	Sample (n)	Sampling Method
TVET trainers	Large and distributed	70	Convenience & Snowball Sampling
TVET trainees	Large and distributed	73	Convenience & Snowball Sampling
Total	**<ΣN>**	**143**	

Table 3.1 *Summary of the Target Population and Sample Size*

3.5 Data Sources

This study utilized both primary and secondary data sources to obtain comprehensive information regarding the challenges of existing e-learning systems and the requirements for developing a hybrid mobile learning framework for Ethiopian government TVET colleges.

1. **Primary Data Sources:** the research's primary data sources are mainly trainers and trainees because they are directly related to The tevt learnng systems **.** The primary data collection methods included online questionnaires and expert interviews. Structured questionnaires were developed using Google Forms and distributed electronically to trainees and trainers from different Ethiopian government TVET colleges. The questionnaire was designed to collect information regarding existing e-learning challenges, internet connectivity issues, and accessibility of learning resources, mobile learning practices, user requirements. In addition to this an expert review was prepared for ICT professionals and educational stakeholders to obtain

expert opinions regarding the feasibility, effectiveness, technical architecture, and applicability of the proposed hybrid mobile learning framework.

2. **Secondary Data Sources** Secondary data were obtained from published Peer-reviewed journal articles, Books and book chapters Master's theses and doctoral dissertation and sources relevant to e-learning, mobile learning, hybrid learning systems, educational technology adoption, and TVET education secondary data sounrces include reputable academic databases and digital libraries, like IEEE Xplore, ScienceDirect, and Google Scholar, and other scholarly sources. The secondary data were primarily used to establish the theoretical foundation, conceptual framework, empirical review, and research gap of the study.

3.6 Data Collection Methods

To collect the data required for this study, multiple data collection instruments were employed, including structured questionnaires, expert evaluation interviews, document analysis, and observation.

3.6.1 Structured Questionnaire Two separate questionnaires were prepared and distributed to trainees and trainers from Ethiopian government TVET colleges using Google form. The questionnaires include 29-31 open ended questions about demographic questions and items related to internet accessibility, e-learning usage, mobile learning practices, accessibility of learning resources, learner engagement, and perceptions of existing e-learning systems. Participants were requested to complete the questionnaires and share them with colleagues and students within their respective institutions.

3.6.2 Expert Evaluation Interviews An expert evaluation instrument consisting of semi-structured questions was prepared for ICT professionals and educational technology experts to obtain technical feedback regarding the proposed hybrid mobile learning framework and the existing e-learning systems implemented within TVET institutions. **The questions mainly focused on** current e-learning system challenges, infrastructure limitations, mobile learning readiness, offline learning feasibility, synchronization mechanisms, framework applicability and recommendations for improvement.

3.6.3 Document Analysis Document analysis was conducted to collect secondary data relevant to e-learning, mobile learning, hybrid learning systems, educational technology adoption, and TVET education. Various sources were reviewed, including journal articles,

and other references. document analysis provided theoretical foundations, empirical evidence, and contextual information used in the development of the proposed framework.

3.6.4 Observation was employed to examine the functionality and characteristics of existing e-learning systems currently used within TVET institutions. The observation mainly focused on system features, accessibility, learning resource management processes, internet dependency, mobile compatibility, and user interaction mechanisms. And the findings were used to identify existing system strengths, limitations, and opportunities for improvement. These findings contributed to the requirement analysis and design of the proposed hybrid mobile learning framework.

3.7 System Development Methodology

This study adopted the Design Science Research (DSR) methodology to guide the development and evaluation of the proposed hybrid mobile learning framework for Ethiopian government TVET colleges. DSR was selected because the primary objective of the study is to design a practical technological artefact capable of addressing real-world educational challenges rather than merely describing or explaining existing phenomena. The study followed the following Design Science Research phases:

Design Science Research Process Applied in the Study
Problem Identification ↓
Define Solution Objectives ↓
Framework Design & Development ↓
Demonstration ↓
Framework Evaluation ↓
Communication of Results

Fig 1. Design Science Research phases

1. Problem Identification and Motivation: The first phase involved identifying and understanding the existing challenges affecting e-learning implementation in Ethiopian government TVET colleges. Information was collected through literature review, questionnaires, interviews, and preliminary observations. Key challenges identified included unstable internet connectivity, inadequate ICT infrastructure, limited accessibility of learning resources, and the absence of offline learning support.

2. Define Objectives for the Solution: Based on the identified challenges and literature review findings, objectives for the proposed solution were established. The framework was designed to improve learning accessibility, support offline learning, enable synchronization between online and offline environments, enhance learner engagement, and provide flexible mobile learning services.

3. Design and Development: In this phase, the hybrid mobile learning framework was designed using mobile-first and offline-first architectural principles. The framework incorporated key components such as the mobile application, SQLite local database, REST API communication, synchronization services, cloud backend server, central database, notification system, learning management services, and multilingual support. The outputs are Conceptual framework and System architecture design

4. Demonstration: The developed framework was presented to ICT professionals, and educational stakeholders for review and discussion. The framework diagram, architecture, and operational processes were explained to participants to demonstrate how the proposed solution addresses identified e-learning challenges.

5. Evaluation: The effectiveness, applicability, and feasibility of the proposed framework were evaluated by using questionnaires and semi-structured interviews. The evaluation process of the framework was assessed by showing the proposed hybrid mobile learning framework to ICT professionals and stakeholders and Compare and contrast with the current E-learning system after observing the current e-learning system the participants are asked whether the framework is useful, feasible, appropriate for Ethiopian TVET colleges and capable of addressing current e-learning challenges. The output of this phase is Evaluation results, Expert recommendations and Framework assessment report

6. Communication: these phase involved documenting and communicating the research findings, framework design, evaluation results, and recommendations through the dissertation report and academic presentation the output of this phase include Dissertation document,

Research findings, Final framework and recommendations**.** Design Science Research methodology was considered appropriate because it provides a structured approach for developing and evaluating a practical framework capable of addressing the identified e-learning challenges within Ethiopian government TVET colleges.

3.8 proposed Tools and Technologies

Component	Technology	Purpose
Mobile Application	**Flutter**	**Cross-platform mobile development**
Local Storage	**SQLite**	**Offline data storage**
Communication	**REST API**	**Data exchange between mobile app and server**
Backend Server	**Node.js / Laravel / Django**	**Business logic and service management**
Central Database	**MySQL**	**Permanent storage of institutional data**
Notifications	**Firebase Cloud Messaging (FCM)**	**Push notifications**
Multilingual Support	**Flutter Localization**	**Support Afaan Oromo, Amharic, and English**

Table 3.2 Summary of proposed Tools and Technologies

3.9 Data Analysis Methods

The collected data will be analysed using both quantitative and qualitative data analysis techniques. Quantitative data will be obtained from the structured questionnaires administered to trainees and trainers, while qualitative data will be obtained from expert evaluations, observations, and open-ended questionnaire responses. The combination of quantitative and qualitative analysis methods will enable comprehensive assessment of existing e-learning challenges and evaluation of the proposed hybrid mobile learning framework.

3.9.1 Quantitative Data Analysis

Quantitative data collected through Google Forms will be exported to Microsoft Excel and excel or (SPSS) will be used for analysis. Prior to analysis, the collected data will be checked for completeness, consistency, duplicate responses, and missing values. The cleaned data will then be coded and organized for statistical analysis. Descriptive statistical techniques will be employed to summarize and present the collected data. These techniques include:

- **Frequency Analysis** Frequencies will be used to summarize demographic characteristics such as gender, age group, educational qualification, teaching experience, and institution.
- **Percentage Analysis** Percentages will be calculated to determine the proportion of respondents corresponding to each response category.
- **Mean Analysis** Mean scores will be calculated for Likert-scale items to determine the average level of agreement among respondents.

3.9.2 Qualitative Data Analysis

Qualitative data obtained from expert evaluation questionnaires, observations, and open-ended survey responses will be analysed using thematic analysis. The analysis will involve reviewing responses Themes such as infrastructure limitations, internet connectivity challenges, offline learning requirements, curriculum alignment, multilingual support, data integration, and framework improvement recommendations will be identified and discussed.

3.9.3 Framework Evaluation Analysis

The proposed hybrid mobile learning framework will be evaluated using expert feedback obtained from ICT professionals and educational technology stakeholders. The evaluation will focus on the framework's feasibility, usability, applicability, scalability, and ability to address the identified e-learning challenges. Expert comments and recommendations will be analysed using thematic analysis. Suggestions

3.9.4 Data Presentation

The analysed data will be presented using frequency tables, percentage distributions, charts, graphs, and thematic summaries. Quantitative findings will be summarized using descriptive statistics, while qualitative findings will be presented through thematic descriptions and supporting participant statements. The results will be used to identify existing e-learning

challenges and to validate the suitability of the proposed hybrid mobile learning framework for Ethiopian government TVET colleges.

3.10 Ethical Considerations

Ethics in research deals about questions on how we formulate and clarify our research topic, design our research and gain access, collect data, process and store our data, analyse data and write up our research findings in a moral and responsible way Therefore, in conducting this research. Each participant was asked to voluntarily participate in the study. The responses of each participant will be kept confidentially In order to ensure that a questionnaire used in a study is ethical; several considerations should be taken into account these may include:

1. Informed consent: Participants should be fully informed about the study and give their consent to participate.

2. Privacy and confidentiality: Participants' personal information should be kept confidential and their answers should be anonymous if possible.

3. Minimizing harm: The questionnaire should not cause harm or distress to the participants.

4. Respect for autonomy: Participants should be able to withdraw from the study at any time without penalty.

5. Fairness: The questionnaire should be designed and administered in a way that is fair to all participants.

6. Transparency: The purpose and methods of the study should be clearly explained to the participants.

7. Deception: Participants should not be deceived about any aspect of the study.

8. Validity: The questionnaire should be designed and administered in a way that will produce valid and reliable results.

9. Bias: Measures should be taken to minimize bias in the selection of participants and in the design and administration of the questionnaire.

3.11 Validity and Reliability

External validity was enhanced by collecting responses from trainees, trainers, and ICT professionals drawn from different Ethiopian government TVET colleges. This approach

enabled the study to obtain diverse perspectives from participants with varying educational and professional backgrounds.

Reliability: Reliability was enhanced by using structured questionnaires with consistent question formats and standardized data collection procedures for all respondents. The same questionnaire was administered to participants under similar conditions to ensure consistency in responses. In addition, questions were designed using simple and clear language to minimize misunderstanding and improve response accuracy.

3.12 Summary

This chapter presented the research methodology employed to achieve the objectives of the study. It described the research design, target population, sampling techniques, data collection instruments, and data collection procedures used to gather information from trainers, trainees, and ICT professionals in Ethiopian TVET colleges. The chapter also explained the methods used to ensure the validity and reliability of the study instruments, as well as the ethical considerations observed throughout the research process.

Furthermore, the chapter outlined the data analysis methods used to examine the collected data. Quantitative data obtained from questionnaires were analyzed using descriptive statistics, including frequencies, percentages, and mean values, while qualitative information gathered from observations and expert evaluations was analyzed using thematic interpretation. The methodology provided a systematic approach for assessing the current e-learning environment, identifying existing challenges, and developing the proposed Hybrid Mobile Learning Framework for Ethiopian TVET colleges.

CHAPTER FOUR: SYSTEM ANALYSIS, DESIGN, IMPLEMENTATION, AND RESULTS

4.1 Introduction

This chapter presents the system analysis, design, implementation considerations, and results of the proposed hybrid mobile learning framework for Ethiopian government TVET colleges.

The questionnaires and interview data's collected from TVET trainer, trainee and ICT professionals were analysed and based on the analyses and literature review, a context-aware hybrid mobile learning framework is proposed and described. The chapter further presents the architectural design, major framework components, and their interactions in supporting online and offline learning activities. Finally, the chapter discusses the evaluation results obtained from stakeholders and experts to assess the feasibility, effectiveness, and applicability of the proposed framework in addressing e-learning challenges within low-connectivity TVET learning environments.

4.2 Existing System Analysis

The existing system currently deployed within Ethiopian government TVET institutions is an integrated educational management platform designed to support academic administration and digital learning services. The system consists of six major modules: Student Information Management System, Digital Library, Learning Management System (LMS), School Portal, Library Management System, and Business Integration Module. In addition, the system provides a mobile application intended to extend access to educational services through mobile devices.

The Learning Management System is intended to facilitate online teaching and learning activities but According to observations and discussions with the system management team Despite the availability of these modules, the system has not been fully implemented and many of the intended e-learning functionalities are not yet effectively utilized. The Learning Management System component, which is expected to support teaching and learning activities, remains underutilized due to technical and infrastructural challenges. The mobile application operates only in online mode and does not provide offline learning capabilities.

As a result, trainees and trainers require continuous internet connectivity to access learning resources and services.

The analysis further revealed that the system requires high internet bandwidth to operate effectively. This presents a significant challenge for TVET colleges located in areas with unstable or limited internet connectivity. Users reported frequent system interruptions and crashes during operation, negatively affecting reliability and user experience. Furthermore, some system features were reported to be non-functional or partially implemented, limiting the overall effectiveness of the platform.

Another limitation identified during the analysis relates to usability. The system interface contains numerous modules and functions, making it complex for many users to understand and navigate. Consequently, extensive training is required before trainers and trainees can effectively utilize the platform. This complexity may reduce user acceptance and slow system adoption across institutions.

The study also found that although the system was designed to support three languages, only the English language interface is currently operational. The absence of fully implemented multilingual support limits accessibility for users who prefer learning and interacting in local languages. In addition, the grading and assessment processes do not fully align with the competency-based assessment structure commonly used within Ethiopian TVET education, creating challenges in academic performance management.

A further challenge concerns data management and system architecture. Each TVET college maintains a separate database instance, resulting in fragmented data storage and management practices. This decentralized approach makes it difficult to achieve centralized reporting, data sharing, and institutional coordination across colleges. Managing multiple independent databases also increases administrative complexity and maintenance requirements.

Strengths of the Existing System

The existing system provides several important benefits:

- Availability of integrated educational management modules.
- Digital registration and management of trainee and trainer information.
- Availability of a mobile application.

- Support for digital library and learning management services.

Limitations of the Existing System

The analysis identified several limitations:

- Dependence on continuous internet connectivity.
- Absence of offline learning functionality.
- High bandwidth requirements.
- Partial implementation of e-learning features.
- Frequent system crashes and performance issues.
- Complex user interface requiring extensive training.
- Incomplete multilingual support.
- Assessment and grading processes not fully aligned with TVET requirements.
- Decentralized databases across institutions.
- Limited support for learning continuity in low-connectivity environments.

Gap Analysis

The findings from the assessment indicates that there is a gap regarding offline learning capabilities, dependence on high-speed internet, fragmented data management, and limited multilingual support restrict the effectiveness of the current system. These limitations justify the development of the proposed hybrid mobile learning framework, which aims to provide offline-first learning support, synchronization capabilities, centralized data management, multilingual accessibility, and improved usability for trainees and trainers operating in diverse connectivity environments.

4.3 Data Presentation and Analysis

4.3.1 Demographic information

GENDER		
TRAINER		
Gender	**Frequency**	**Percentage (%)**
Male	**43**	**61.4**
Female	**27**	**38.6**
total	**70**	**100**
Trainee		
Male	**49**	**67.1**
Female	**23**	**31.5**
missing	**1**	**1.4**
total	**73**	**100**
AGE		
TRAINEE		
Age Group	**Frequency**	**Percentage %**
≤ 30 years	66	90.4%
31–40 years	5	6.8
41–50 years	1	1.4%
Missing	1	1.4%
Total	**73**	**100.0**
TRAINER		
Age Group	**Frequency (f)**	**Percentage (%)**
≤ 30 Years	31	44.3
31–40 Years	35	50.0
41–50 Years	4	5.7
Total	70	100.0
LOCAION OF RESPONDANT		
TRAINER		
Location	**Frequency (f)**	**Percentage (%)**

Peri-Urban	34	48.6
Urban (e.g., Addis Ababa)	32	45.7
Rural	4	5.7
Total	**70**	**100.0**
TRAINEE		
Location	**Frequency (f)**	**Percentage (%)**
Semi-Urban	25	34.2
Urban (main cities)	43	58.9
Rural	5	6.9
Total	**73**	**100.0**

Table 2 demographics data analysis

Based on the respondent's survey report from total 70 Trainer shows 61.4% or 43 of them are males. The rest 27 of them are females. The other demographic information is age, from 70 respondents 44.3% or 31 of them are <= 30 years, 50% or 35 of them are between age of 31-40 years. The rest 5.7% or 4 of them are between 41-50 years. In addition, the location of respondent indicates that 48.6 % or 34 of them are from Peri-Urban ,45.7% or 32 of them are from urban (central cities) the rest 5.7% or 4 of them are from rural areas.

On the other hand Based on the respondent's survey report from total 73 trainee responses **67.1**% or 49 of them are males. The rest 31.5% or 23 of them are females the rest is missing data . The other demographic information is age, from 73 respondents 90.4% or 66 of them are <= 30 years, 6.8% or 5 of them are between age of 31-40 years and 1 respondent is between 41-50 years. In addition, the location of respondent indicates that 58.9% trainees are from urban (central cities), 34.2% are from semi urban cities and the res 6.9% are from rural areas .all this demographics analysis indicates that male trainees and trainers constituted a larger proportion of the respondents participating in the study. Regarding age responses most trainee respondents were aged 30 years or below. This indicates that the study participants were predominantly young trainees, making mobile learning technologies highly relevant to the target population. On the other hand location of respondents is mostly from urban and semi urban areas which makes it diverse for location diversity which is helpful because the mobile off line framework is designed for low infrastructure areas .

4.3.2 Technology access and Infrastructure

- Smartphone ownership
- Internet access
- Electricity availability

Internet access respondents

Trainees		
Variable	**Result**	Percentage
Yes, but unstable	56	76.7
Yes, reliable	11	15.1
No internet access	5	6.8
missing	1	1.4
total	73	100
Trainers		
Response	**Frequency (f)**	**Percentage**
Yes, but unstable	51	72.9
Yes, reliable	6	8.6
No	7	10.0
No Response	6	8.6
Total	70	100.0

Table 3Internet access of respondents

This analysis shows that most trainers and trainees reported having internet access, but indicated that the connection is unstable. Only 15.1% of trainees and 8.6 %trainers reported having reliable internet access,. This indicates that internet connectivity remains a significant challenge for effective e-learning implementation in TVET colleges. And off line learning capability is the major step to increase eLearning acceptance and implementation

Smartphone Ownership of respondents

Trainees		
Response	**Frequency**	**Percentage (%)**
Yes	61	83.6
No	9	12.3
missing	3	4.1
Total	73	100

Trainers		
Response	**Frequency (f)**	**Percentage (%)**
Yes	65	92.9
No	5	7.1
Total	**70**	**100.0**

Table 4 Smartphone Ownership of respondents

Most trainers (92.9%) and trainees (83.6%) owned a personal smartphone. This finding indicates a high level of readiness for mobile-based learning solutions and supports the feasibility of proposing a hybrid mobile learning framework.

Availability of Electricity responses

Trainees		
Availability of Electricity	**Frequency**	**Percentage (%)**
Frequently interrupted	36	49.3
Occasionally interrupted	23	31.5
Always available	8	11
Rarely available	5	6.8
No Response	1	1.4
Total	**73**	**100.0**
Trainers		
Response	**Frequency**	**Percentage (%)**
Frequently interrupted	41	58.6
Occasionally interrupted	18	25.7
Rarely available	7	10.0
Always available	3	4.3
No Response	1	1.4
Total	70	100

Table 5 Availability of Electricity responses

- This indicates that there is not a constant electric supply in most places, this affects the internet and Wi-Fi service and also not suitable for desktop users unless there is backup services like generator so it can be taken that the mobile first and offline first approach is suitable

4.3.3 Current E-learning environment

ELearning availability

Trainee		
Response	**Frequency (f)**	**Percentage (%)**
yes	44	60.3
no	27	37.
missing	2	2.7
total	73	100

trainer		
Response	**Frequency (f)**	**Percentage (%)**
No	57	81.4
Yes	13	18.6
Total	**70**	**100.0**
Total	**70**	**100.0**

Table 6*ELearning availability*

The analyses show that most trainers of trainees reported that their colleges do not have e-learning technology; this finding demonstrates a low level of e-learning implementation in the surveyed TVET colleges and highlights the necessity of developing a hybrid mobile learning framework to enhance technology-supported teaching and learning practices.

Type of learning currently used

TRAINER		
E-Learning Approach	**Frequency**	**Percentage (%)**
Face-to-face learning only	64	91.4
Social media platforms (WhatsApp, Telegram, etc.)	32	45.7
Recorded video lessons	13	18.6
Blended learning (online + face-to-face)	6	8.6
Learning Management Systems (Moodle, Teams, etc.)	4	5.7
Fully online learning	2	2.9
TRAINEE		
E-Learning Approach	**Frequency**	**Percentage (%)**
Manual face-to-face learning	60	82.2
Use of social media platforms (e.g., , Telegram groups)	47	64.4
Recorded video lessons (e.g., YouTube, TV broadcasts)	7	9.6
Blended learning (combination of online and face-to-face)	5	6.8
Fully online courses	3	4.1
Learning Management Systems (e.g., Moodle, Microsoft Teams)	4	5.5

Table 78 Type of learning currently used

Based on the analysed data manual face to face learning is the most widely used approach towards both trainer and trainee respondents, next to that ***social media platforms such as WhatsApp and Telegram*** were the most commonly used, to towards respondents .indicating their use. Therefore by these findings I can be implied that both trainers and trainees are familiar with mobile and social media technologies. The results support the development of a ***Hybrid Mobile Learning Framework*** that leverages widely available on mobile devices and social media familiarity while providing more structured learning functionality.

4.3. 4 Current system and recommended system evaluation

Mean Analysis of Likert Scale Questions

Mean Range	Interpretation
1.00 – 1.80	Strongly Disagree
1.81 – 2.60	Disagree
2.61 – 3.40	Neutral
3.41 – 4.20	Agree
4.21 – 5.00	Strongly Agree

Table 9 Mean Analysis of Likert Scale Questions

Mean Scores of Key Statements

Statement	Mean	Interpretation
Internet access is affordable for me	**1.89**	Disagree
The current e-learning system is easy to use and supports interaction	**2.42**	Disagree
The current e-learning system supports effective communication	**2.79**	Disagree
Mobile learning would improve accessibility	**3.37**	Neutral
Offline learning functionality would improve learning continuity	**3.30**	Neutral

Table 10 Mean Scores of Key Statements

The overall analyses indicate that respondents are not fully satisfied with the current eLearning approach they are using however regarding mobile learning acceptance they show positive responses these findings provide evidence for adopting mobile-supported and offline-capable e-learning approaches in TVET colleges.

The analysis revealed several challenges affecting the effectiveness of the current e-learning environment in Ethiopian TVET colleges. These include unstable internet connectivity, poor infrastructure, inadequate communication support, lack of integration between systems, and absence of offline learning capabilities. The findings also indicate widespread ownership of smartphones among trainees, suggesting that a mobile-based learning approach is feasible. Consequently, the proposed hybrid mobile learning framework incorporates offline learning, centralized data management, API integration, curriculum management, TVET grading support, and a managerial dashboard to address the identified challenges

4.3.5 Document analysis

I have reviewed some documents related to the current eLearning system to have a better understanding, the data's indicate that the current system is evaluated by different it professionals and trainers to evaluate its functionality the evaluation data indicates that there are many gaps identified in the current system which needs correction some comments include

- The online exam scheduling feature is currently non-responsive and not functioning properly. This issue prevents users from scheduling or accessing online exams as intended.
- **Duplicate Registrations:** Implement a mechanism to prevent or identify cases where a student is registered multiple times, either within the same school or across different schools.
- The system lacks consistency
- The system is not fully developed, which complicates the training process as it involves incomplete modules. This incompleteness makes it challenging for users to effectively learn and use the system.
- The system is not stable, and the loading time is very slow
- **This comments that is mention in the current system can be used to strength the framework and additional features**

4.4 Proposed System

Proposed Hybrid Mobile Learning Framework

To address the limitations identified in the existing system, this study proposes a Hybrid Mobile Learning Framework designed specifically for Ethiopian government TVET colleges. The framework integrates mobile learning technologies, offline learning capabilities, centralized data management, and synchronization services to provide a flexible and accessible learning environment for trainees and trainers operating under varying connectivity conditions.

The proposed framework follows an offline-first architecture that enables users to access learning materials, assignments, announcements, and other educational resources even when internet connectivity is unavailable. Learning content downloaded during online sessions is stored locally on the learner's mobile device using a lightweight local database. When internet connectivity becomes available, the framework automatically synchronizes locally stored data with the central server through secure communication services.

The framework consists of several interconnected components, including a mobile application layer, local storage layer, synchronization services, application server, central database, notification services, communication services, and multilingual support modules. The mobile application serves as the primary interface through which trainees and trainers interact with the system. The local storage component enables offline access to learning materials, assignments, quizzes, and notifications. Synchronization services ensure that updates made while offline are automatically uploaded to the central server when connectivity is restored.

Unlike the existing system, which requires continuous internet connectivity, the proposed framework supports both online and offline learning activities. This capability reduces dependence on high-bandwidth internet connections and improves accessibility for learners located in areas with limited network coverage. Furthermore, the framework utilizes a centralized database architecture that allows data from multiple TVET colleges to be managed and coordinated more efficiently, overcoming the challenges associated with maintaining separate institutional databases.

The proposed framework also incorporates multilingual support, enabling users to access the system in English, Afaan Oromo, and Amharic. This feature improves usability and accessibility for a diverse user population. In addition, integrated communication and

notification services facilitate interaction between trainees, trainers, and administrators, thereby enhancing learner engagement and educational continuity.

The framework further supports competency-based learning processes by providing flexible mechanisms for managing learning resources, assignments, assessments, and progress tracking. This improves alignment with the educational structure and requirements of Ethiopian TVET institutions.

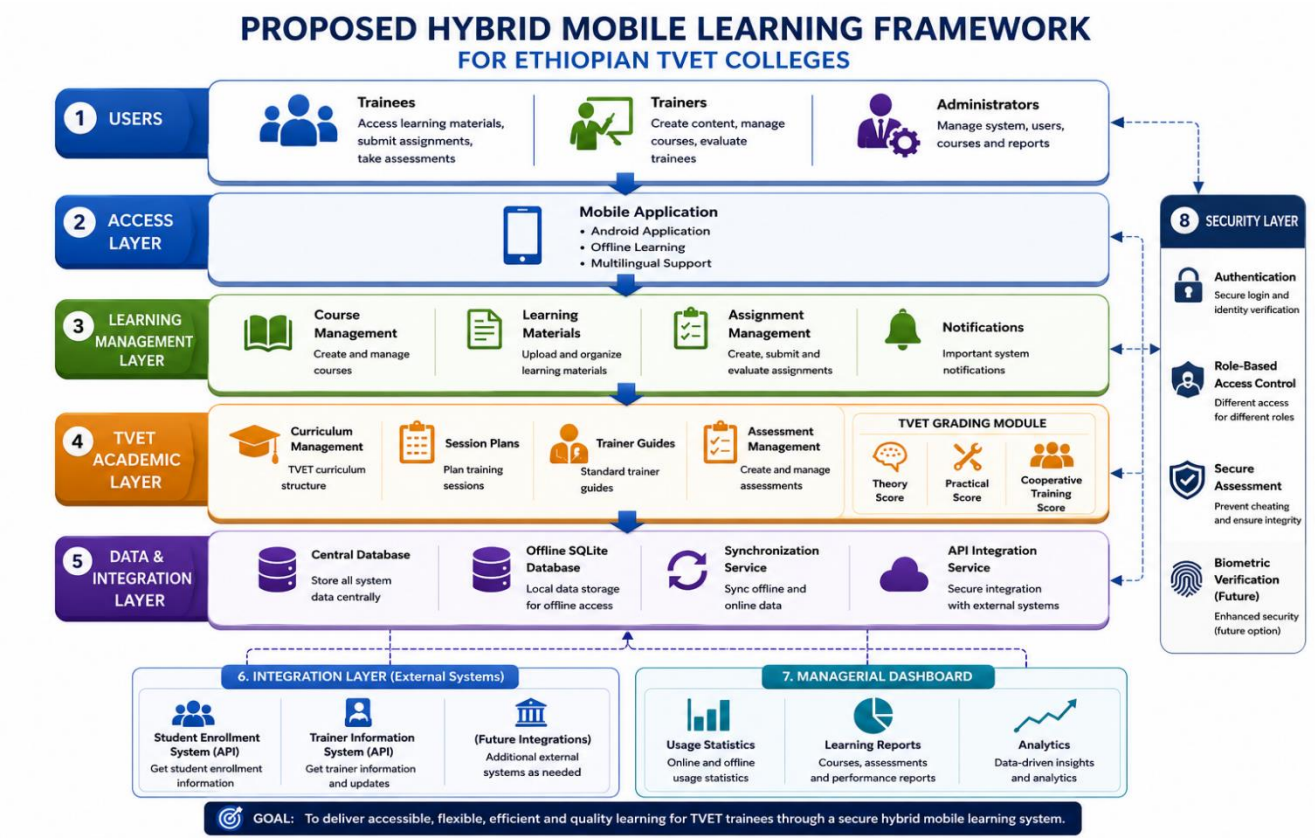


Figure 2 proposed hybrid mobile framework

Framework description

1. Users Layer This layer contains the primary system users: **Trainees**, **Trainers** and **Administrators**

2. **Access Layer** This layer provides access to the system through a mobile application.

3. **Learning Management** Layer This layer manages learning activities and educational resources. Which include

- Course Management
- Learning Materials

- Assignment Management
- Notifications

4. **TVET Academic Layer** This layer supports TVET-specific academic processes. Which include Curriculum Management, Session Plans, Trainer Guides, Assessment Management and grading

5. **Data and Integration Layer** This layer manages data storage and synchronization. Using MySQL

- Central Database
- Offline SQLite Database
- Synchronization Service
- External API Integration

6. **Integration Layer** This layer connects the framework with external government and educational systems.

7. **Managerial Dashboard** This layer supports institutional monitoring and decision-making. By using Usage Statistics, Learning Reports Analytics Dashboard

8. **Security Layer** This layer protects system resources and user information.

4.4 Requirement Analysis

4.4.1 Functional Requirements

The requirement analysis phase was conducted to identify the functional and non-functional requirements necessary for the proposed hybrid mobile learning framework. The requirements were derived from questionnaire responses, expert evaluations, observation of the existing system, and findings from the literature review. The identified requirements serve as the foundation for the design of the proposed framework and ensure that it addresses the challenges faced by trainees and trainers in Ethiopian government TVET colleges.

4.4.1 Functional Requirements

Functional requirements describe the services and operations that the proposed framework must perform to support teaching and learning activities.

The proposed hybrid mobile learning framework shall:

1. Allow trainees and trainers to securely log into the system.
2. Enable trainees to access course materials through mobile devices.
3. Allow users to download learning materials for offline access.
4. Enable trainers to upload learning resources, assignments, and announcements.
5. Support automatic synchronization of data between local storage and the central server when internet connectivity becomes available.
6. Allow trainees to submit assignments through the mobile application.
7. Enable trainers to evaluate and provide feedback on submitted assignments.
8. Support notifications for assignments, announcements, assessments, and learning activities.
9. Facilitate communication between trainees and trainers through messaging features.
10. Allow users to track learning progress and course activities.
11. Support multilingual interfaces including English, Afaan Oromo, and Amharic.
12. Enable administrators to manage users, courses, and learning resources.
13. Support centralized storage and management of institutional data.
14. Allow trainees to access previously downloaded learning resources without an internet connection.
15. Maintain synchronization logs and update records between local and central databases.
16. The system shall integrate with existing TVET information systems through APIs.
17. The system shall provide administrative dashboards and reports.
18. The system shall support curriculum-based course organization.

4.4.2 Non-Functional Requirements

Non-functional requirements describe the quality attributes and operational characteristics that the framework should possess.

Usability The framework should provide a simple, user-friendly, and mobile-friendly interface that can be easily understood by trainees and trainers with varying levels of digital literacy.

Accessibility The system should support access from different locations and devices and provide multilingual support to accommodate diverse users.

Availability The framework should remain accessible even when internet connectivity is unavailable through offline learning capabilities.

Reliability The framework should ensure consistent operation and maintain data integrity during synchronization and learning activities.

Performance The system should provide acceptable response times and efficient synchronization of data while minimizing bandwidth consumption.

Scalability The framework should be capable of supporting multiple TVET colleges, trainees, trainers, and educational resources without significant degradation in performance.

Security The framework should protect user information through authentication, authorization, and secure communication mechanisms.

Maintainability The architecture should be modular and flexible to support future updates, feature enhancements, and system maintenance activities.

Compatibility The framework should support a wide range of Android-based mobile devices commonly used by trainees and trainers.

4.5 System Design

The system has a multilayer architecture designed to enable both online and offline learning a ctivities at Ethiopian government TVET colleges. The architecture integrates mobile technologies, local data storage, synchronization services, centralized data management, and communication services that enables trainees and trainers to continue accessing learning materials even when internet connectivity is unavailable. Whenever network connectivity is restored, synchronization services automatically exchange updates between the local database and the central server.

Architecture Components

1. Mobile Application layer

The main interface that trainers and trainees use to communicate with the system is the Mobile Application Layer.Learning resources, assignments, announcements, tests, notificatio ns, and communication services are all accessible through the mobile application.The progra m is made to run on Android tablets and smartphones, which are frequently found in TVET i nstitutes.

3. **Local Storage layer**

   SQLite is used by the Local Storage Layer to store temporary activity logs, user profil es, assignments, and downloaded learning materials on the user's device.By enabling users to access instructional materials without constant internet connectivity, this com ponent facilitates offline learning.

3. Synchronization Layer

Consistency between locally stored data and the central database is maintained via the Synchronization Layer. The synchronization service receives fresh updates from the server and uploads locally created data whenever internet connectivity becomes available. This method reduces bandwidth usage while guaranteeing that consumers always have access to the most recent information

.4. REST API Layer

The mobile application and the server-side components communicate via the REST API. Authentication, course management, learning resources, assignment submission, notifications, and synchronization tasks are all handled by it. The REST API enables secure and standardized data exchange between client and server components.

5. Application Server Layer

Business logic and user-system resource interactions are handled by the Application Server. Authentication, user management, content management, assignment processing, communication services, and synchronization tasks are all handled by it. The server acts as the central coordination point of the framework.

6. Central Database Layer

Components like User accounts, course details, learning materials, assignments, grades, announcements, and synchronization records are all stored in the Central Database. The suggested structure makes use of centralized data management to enhance consistency, reporting, and administrative effectiveness in contrast to the current approach, which requires institutions to maintain separate databases.

7. Notification Service

Alerts and reminders about assignments, tests, announcements, and system events are sent by the Notification Service. This element assists instructors and trainees in staying up to date on significant learning occasions and due dates.

8. Multilingual Support Module

The framework supports multi languages in order to enhance usability and accessibility for users with a variety of language backgrounds.

Architecture Workflow

The framework operates through the following process:

1. Users access the system through the mobile application.
2. Learning materials are downloaded and stored in the local SQLite database.
3. Users continue learning activities even when internet connectivity is unavailable.
4. Assignments, assessments, and activity records are stored locally during offline operation.
5. When connectivity is restored, the synchronization service exchanges updates with the application server through REST APIs.
6. The application server processes requests and stores data in the central database.
7. Notifications and communication messages are distributed to users through the notification and messaging services.
8. Updated information is synchronized back to users' devices.

The proposed architecture therefore provides a scalable, reliable, and context-aware solution capable of addressing connectivity, accessibility, and data management challenges currently affecting e-learning implementation within Ethiopian government TVET colleges.

4.5.1 System Architecture

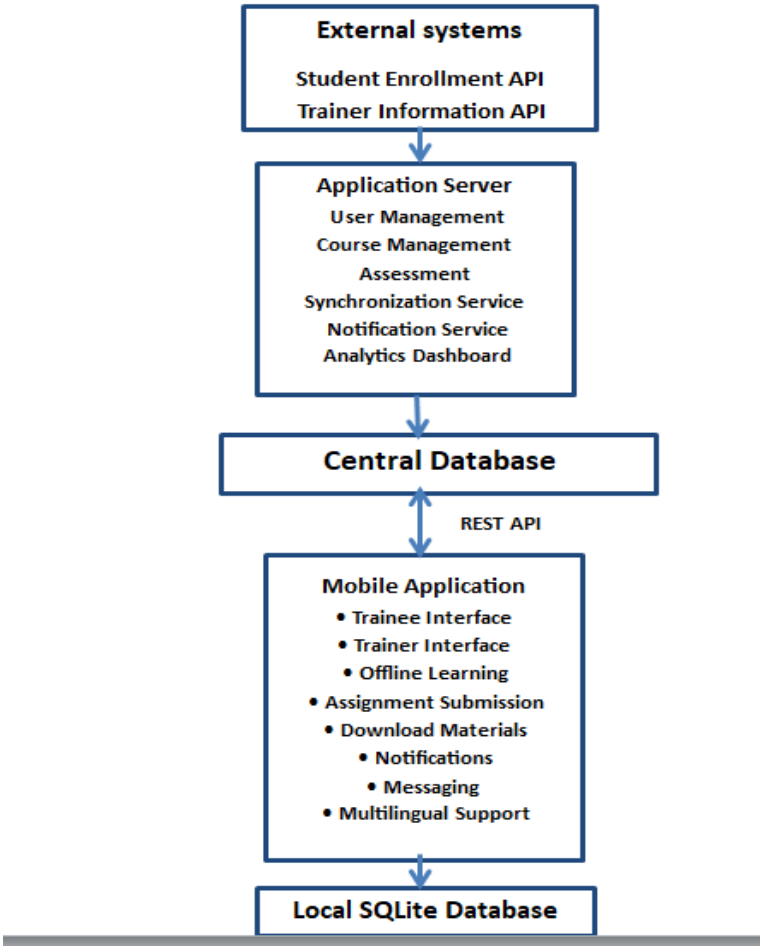


Figure 3 *Proposed System Architecture (existing system demonstration literatures : the researcher, <2026>)*

4.5.2 Use Case Diagram

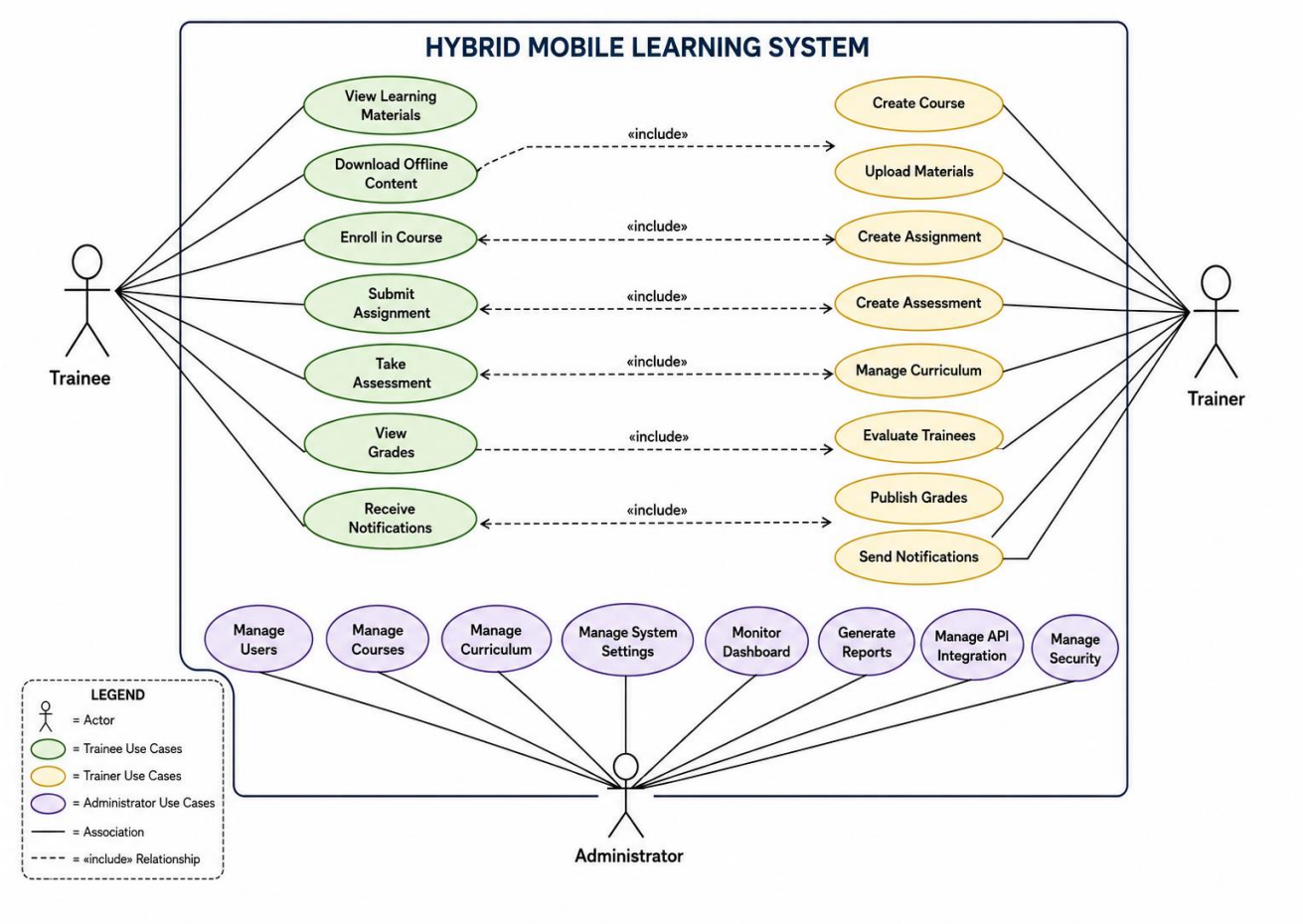


Figure 4*Use Case Diagram of the Proposed System*

Three main actors are involved in the proposed Hybrid Mobile Learning Framework: administrators, trainers, and trainees. Enrolment in courses, access to learning resources, offline learning content downloads, assignment submission, assessment participation, and grade viewing are all available to trainees. Trainers are in charge of creating courses, uploading educational resources, creating tests, and keeping track of grades. Using the administrative dashboard, administrators oversee users, curricular content, API integrations, and system activity. Together, these use cases help Ethiopian TVET institutions provide flexible, accessible, and effective learning.

4.5.3 Data Flow Diagram

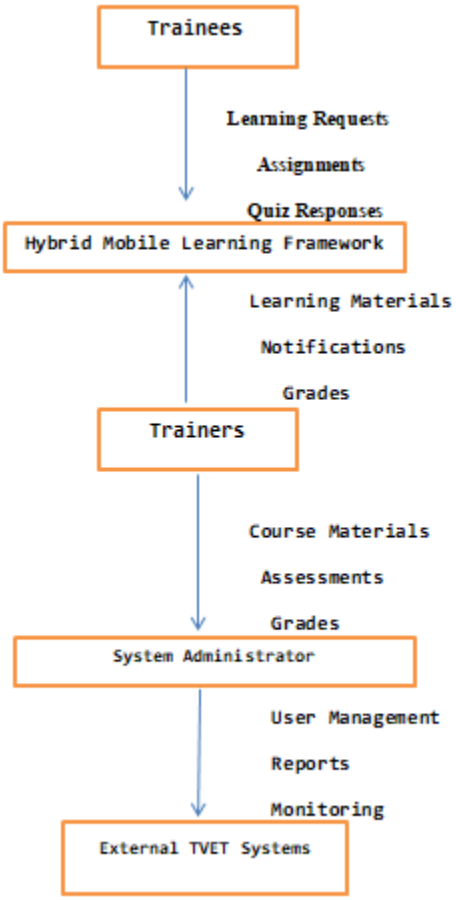


Figure 5Level-0 DFD (Context Diagram)

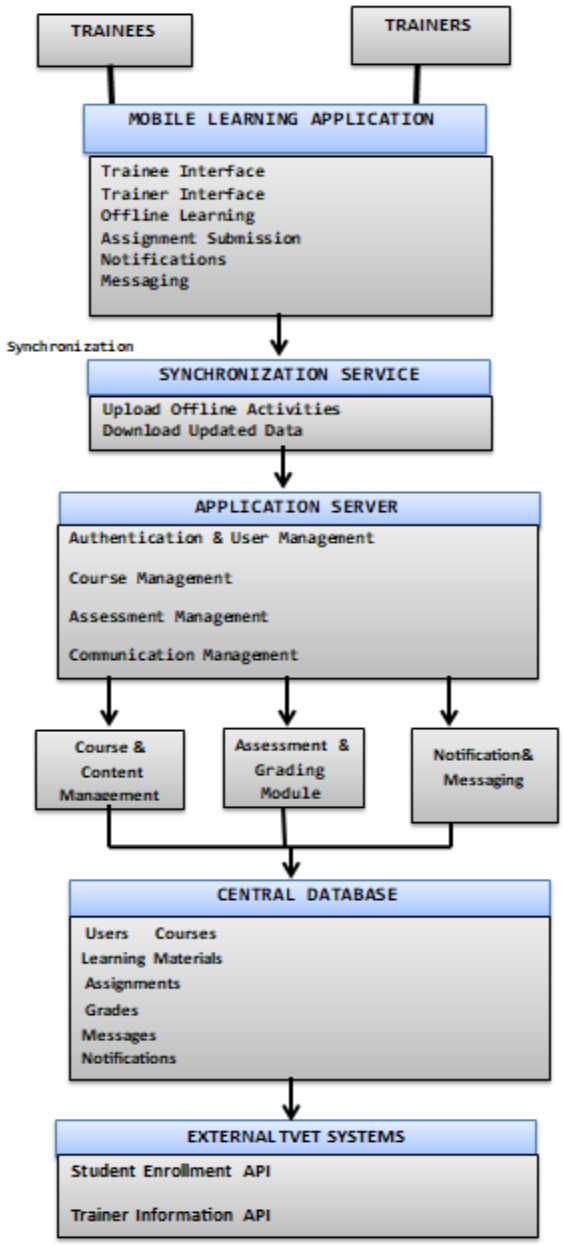


Figure 6*Figure Data Flow Diagram (Level 1)*

Process 1: Mobile Learning Application Provides learning services to trainees and trainers. Supports offline learning and Enables assignment submission and access to learning materials.

Process 2: Synchronization Service Synchronizes locally stored data with the central server and Uploads offline activities when internet connectivity becomes available.

Process 3: Application Server Processes user requests Manages authentication, course delivery, assessment, and communication services.

Course & Content Management Manages courses, learning materials, trainer guides, and session plans.

Assessment & Grading Module Records theory, practical, and cooperative training scores and Calculates grades according to TVET requirements.

Notification & Messaging Module Sends notifications and supports trainer-trainee communication.

Central Database Stores all user, course, assessment, and communication data.

External Systems Integrates with student enrolment systems and trainer information systems through APIs.

4.5.4 Entity Relationship (ER) Diagram

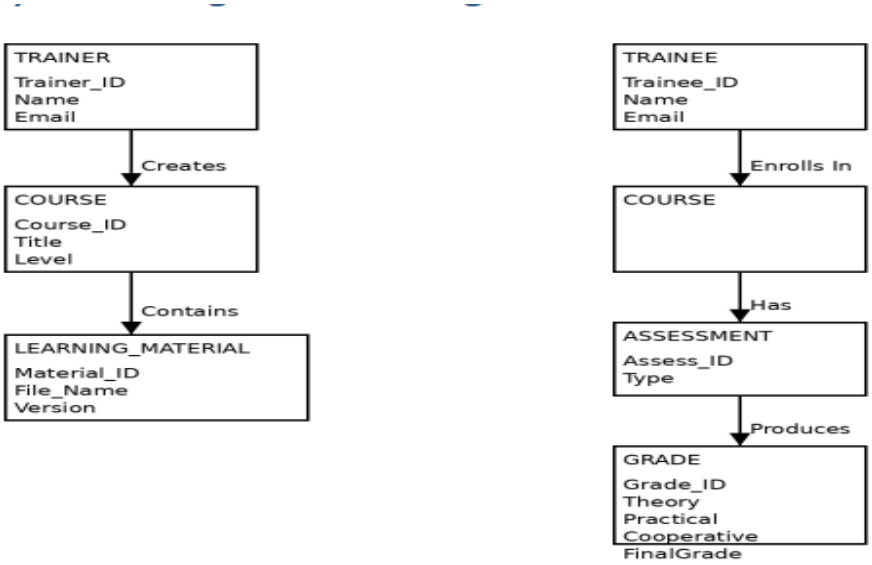


Figure 7 *Entity Relationship (ER) Diagram*

Trainee:-Stores trainee information and course enrolment data.

Trainer:-Stores trainer information and course management activities.

Course:-Represents TVET courses offered through the framework.

Learning Material:-Stores resources, session plans, and trainer guides.

Curriculum:-Maintains standardized TVET curriculum versions.

Assessment:-Stores quizzes, assignments, and examinations.

Grade:-Stores theory, practical, cooperative training scores, and final grades.

System API:-Represents integration with external enrolment and trainer information systems.

4.7 Testing and Evaluation

The study concentrated on the design of a Hybrid Mobile Learning Framework rather than the development of a fully functional software system. Therefore , stakeholder evaluation and expert review were used to examine the suggested framework. The framework's functionality, usability, viability, and appropriateness for Ethiopian TVET colleges were evaluated by ICT specialists, trainers, and experts in educational technology. The framework's capacity to handle issues such inconsistent internet access, a lack of support for offline learning, disjointed datasets, poor system integration, and insufficient monitoring methods was the main emphasis of the review. The final framework design took into account the evaluators' input.

4.8 Results and Discussion

This section presents and discusses the findings of the study in relation to the research questions and objectives. The results obtained from questionnaire responses, existing system analysis, observations, and expert evaluations were used to assess the current state of e-learning platforms in Ethiopian TVET colleges, identify existing challenges, and develop an appropriate hybrid mobile learning framework.

Research Question 1: What are the prevalent e-learning platforms used in Ethiopian TVET colleges?

The results showed that formal e-learning is still not widely used in most of the TVET colleges. 91.4% of trainers and 82.2%of trainee respondents mentioned using manual face to face learning and on average 55.5% respondents mentioned social media platforms like Telegram and WhatsApp for educational communication and resource sharing, Even though government TVET colleges have implemented and integrated educational management platform, its Learning Management System component is not being effectively exploited, according to the examination of the current system. Most colleges currently use the platform mainly for trainee registration, trainer information management, and administrative services rather than supporting complete online teaching and learning activities. This findings indicate that if there is simply understandable, easily accessible mobile based platform then trainers and trainees can easily engage and use just like other social media platforms mentioned

Research Question 2: What challenges do educators and students face when utilizing these e-learning platforms?

The study found a number of organizational, technological, infrastructure, and usability issues that have an impact on how e-learning technologies are implemented and used at TVET colleges.

One of the biggest obstacles was found to be internet connectivity. Most responses regarding internet indicates that there is internet available but it is not consistent these results show that many users work in settings where it is not possible to guarantee constant access to the internet.

Another significant issue was the supply of electricity. While trainers reported both occasional and frequent power outages, more than half of trainee responders reported regular power outages. These conditions negatively affect access to digital learning resources and reduce the reliability of online learning systems.

The current system assessment revealed more challenges. The smartphone app only works online; it does not support offline learning. The platform requires a significant amount of internet traffic, has some unfinished features, and crashes and interruptions regularly. Furthermore, multilingual capability is still lacking despite early aspirations to support multiple languages. Data management is another significant obstacle. Individual institutions retain separate databases, which leads to fragmented information management, reporting hurdles, and institutional coordination issues.

These results show that the current e-learning systems are limited by inadequate alignment with TVET educational objectives, poor infrastructure, unstable connectivity, usability issues, and limited adaptability. Collectively, these barriers reduce the effectiveness of digital learning initiatives and limit the widespread adoption of e-learning technologies within Ethiopian TVET colleges.

Research Question 3: How can these challenges be addressed and what solutions can be proposed?

This study suggested a Hybrid Mobile Learning Framework specifically designed for Ethiopian TVET colleges based on the difficulties found. Results from respondents, observations, analysis of the current system, and expert assessments were used to create the framework.

Training materials, assignments, tests, and announcements can be accessed by trainers and trainees without constant internet connectivity thanks to the proposed framework's offline-first learning architecture. Mobile devices store educational content locally, which is immediately synchronized with the central server upon the availability of internet connectivity. The frequent power outages and erratic connectivity found during the study are directly addressed by this functionality.

To address data fragmentation, the framework incorporates a centralized database architecture that enables data sharing, reporting, and coordination across multiple TVET institutions. This overcomes the limitations associated with maintaining separate institutional databases.

Expert evaluation further strengthened the framework; ICT professionals suggested integrating external systems through APIs to facilitate student enrolment verification and trainer information management; as a result, an API integration layer was incorporated into the framework; additional recommendations included support for desktop access, enhanced security mechanisms for assessments, and grading functionality in line with TVET competency-based assessment requirements; and curriculum management features guarantee that all institutions have access to standardized and updated learning materials, trainer guides, and session plans. The proposed framework therefore incorporates offline learning support, centralized data management, curriculum standardization, API integration, synchronization services, notification mechanisms, managerial monitoring tools, and TVET-specific grading support. These components collectively address the major limitations identified in the existing system.

4.9 Summary

This chapter presented the analysis of the existing e-learning system, data presentation and analysis, requirement analysis, and the design of the proposed Hybrid Mobile Learning Framework for Ethiopian TVET colleges. The findings revealed that although some digital learning technologies are available, their utilization remains limited due to challenges such as unstable internet connectivity, frequent electricity interruptions, poor infrastructure, lack of offline learning support, system usability issues, fragmented databases, and limited alignment with TVET-specific educational requirements.

Based on the identified challenges and requirements, a Hybrid Mobile Learning Framework was proposed to improve learning accessibility, continuity, and effectiveness within TVET institutions. The framework incorporates offline learning functionality, synchronization services, centralized data management, multilingual support, curriculum management, API integration, notification services, managerial dashboards, and TVET-specific grading mechanisms.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusion and recommendations of the study. The conclusion summarizes the major findings obtained from the assessment of existing e-learning platforms in Ethiopian TVET colleges, the challenges affecting their implementation, and the proposed Hybrid Mobile Learning Framework developed to address these challenges. The chapter also discusses the contributions of the study in relation to the research objectives and research questions. Finally, recommendations are provided for TVET institutions, policymakers, system developers, and future researchers to support the successful implementation and further improvement of mobile-based learning solutions in Ethiopian TVET colleges.

5.2 Summary of Major Findings

1. By **assessing the current state of e-learning platforms in TVET colleges** study found that Fully designed and working e-learning practices are no implemented integrated educational management system is available in many institutions but its e-learning functionalities are not fully utilized. Most teaching and learning activities continue to rely on traditional face-to-face instruction. Beside this social media platforms such as Telegram and WhatsApp are commonly used for communication and resource sharing which indicates they are used on mobile phones because of their simplicity and easy accessibility.

2: The study identified several challenges affecting the effective use of e-learning technologies in TVET colleges. Some major challenges included unstable internet connectivity, frequent electricity interruptions, lack of offline learning support, high bandwidth requirements, system usability issues, incomplete multilingual support, fragmented databases, and limited alignment with TVET competency-based assessment requirements. In addition, respondents indicated that the existing system does not adequately support communication and interaction, making it difficult for trainees and trainers to fully benefit from digital learning services.

4. Based on the identified challenges and user requirements, the study proposed a Hybrid Mobile Learning Framework specifically designed for Ethiopian TVET

colleges. The framework incorporates offline learning functionality, synchronization services, centralized data management, multilingual support, curriculum management, API integration, notification services, managerial dashboards, and TVET-specific grading mechanisms. The proposed framework was designed to improve accessibility, learning continuity, system usability, and institutional coordination while addressing the limitations identified in the existing system.

5.3 Conclusion

In this research process, to achieve the targeted objective by solving the identified problem, several procedural activities were performed to this end. The primary activity was to assess the current state of e-learning platforms in Ethiopian TVET colleges, identify the challenges affecting their utilization, and propose a hybrid mobile learning framework capable of addressing these challenges. by performing this The findings revealed that although some TVET institutions have adopted digital learning technologies and educational management systems, their implementation remains limited and many of the intended e-learning functionalities are not effectively utilized. The study identified several barriers, including unstable internet connectivity, frequent electricity interruptions, lack of offline learning support, system usability issues, fragmented data management, incomplete multilingual support, and limited alignment with TVET-specific educational requirements. Therefore it is possible that a hybrid mobile learning approach provides a practical and contextually appropriate solution for improving learning accessibility, continuity, and effectiveness in Ethiopian TVET colleges. The proposed framework addresses the major limitations of the existing system and provides a foundation for enhancing digital learning services in environments characterized by limited infrastructure and unreliable internet connectivity. Therefore, the study concludes that the proposed Hybrid Mobile Learning Framework has the potential to support more flexible, accessible, and sustainable e-learning implementation within Ethiopian TVET institutions.

5.4 Contributions of the Study

Theoretical Contribution: The study identified key technological, infrastructural, and organizational factors affecting e-learning implementation in Ethiopian TVET colleges and proposed a context-specific Hybrid Mobile Learning Framework that integrates mobile learning, offline learning capabilities, and centralized educational services. It is Ethiopian context aware framework so it can serve as a reference for future studies related to mobile learning and digital education in developing countries.

Practical / Technical Contribution: The key practical contribution of this study is the building of a Hybrid Mobile Learning Framework adapted to the demands of Ethiopian TVET institutions. It provides a structured solution for addressing the limitations of existing e-learning systems and can serve as a foundation for future software development and implementation efforts within TVET colleges.

Institutional Contribution this research provides potential benefits to FDRE TVET institutions and other educational stakeholders by offering a more flexible and accessible approach to digital learning. The framework addresses challenges related to unreliable internet connectivity, fragmented data management, and limited learning accessibility. By supporting centralized information management and offline learning functionality, it can improve educational service delivery, learner engagement, and institutional coordination across TVET colleges.

Policy Contribution The study highlights the importance of developing learning systems that accommodate infrastructure limitations while promoting equitable access to education. It also shows that there is a need to expand digital learning policies, standards, and strategies related to e-learning implementation, mobile learning technologies, educational system integration, and digital skills development within Ethiopian TVET institutions.

5.5 Recommendations

5.5.1 Recommendations for FDRE TVET Institutions

The research recommends that FDRE TVET institutions should consider adopting and implementing the proposed Hybrid Mobile Learning Framework to improve the accessibility, flexibility, and effectiveness of e-learning services. And the TVET Institutions should prioritize the provision of digital learning resources, strengthen ICT infrastructure, and promote the use of mobile learning technologies. In addition, continuous training should be provided to trainers, trainees, and administrators to improve digital literacy and enhance the effective utilization of e-learning systems.

5.5.2 Recommendations for the Industry and System Developers

For the industry and system developers the research recommends that the man goal for system development should be based on ease of use and user engagement because from the existing system it can be easily understand that well developed systems are good but also users must easily understand what the system intends to do without confusion . Future e-learning solutions should be designed with the realities of low-connectivity environments in mind and should support interoperability through API integration. Developers should also ensure that learning platforms align with competency-based TVET assessment and grading requirements.

5.5.3 Recommendations for Policymakers and Government

The main stakeholders of Ethiopian TVET system should strengthen investments in digital infrastructure, internet connectivity, and reliable power supply within TVET institutions. Policymakers should encourage the development and adoption of standardized e-learning platforms that support centralized data management and system integration across institutions. Furthermore, policies promoting multilingual digital learning content and equitable access to educational technologies should be developed and implemented.

5.5.4 Recommendations for Researchers

Future researchers should extend this study by implementing and evaluating a working prototype based on the proposed Hybrid Mobile Learning Framework. Additional studies may investigate the effectiveness, usability, performance, and user acceptance of the

framework in real educational environments. Researchers may also explore advanced technologies such as learning analytics, artificial intelligence, adaptive learning, and biometric-based assessment security to further enhance mobile learning systems within TVET institutions.

5.6 Future Work

The primary focus of this study was to propose a Hybrid Mobile Learning Framework for Ethiopian TVET colleges, and to show mobile learning can be an effective way to increase student's engagement but several opportunities remain for further research and development. Future studies should extend the research by involving a larger number of TVET institutions, private and NGO TVET institutions from different regions of Ethiopia to improve the generalizability and applicability of the findings. Additional investigations may also explore the needs and experiences of other stakeholders, including administrators, policymakers, and industry partners involved in TVET education.

In order to evaluate the suggested framework's usability, efficacy, performance, and user acceptability in actual educational settings, future researchers need build and test a fully functional prototype. Advanced features like learning analytics, AI-based learning support, adaptive learning methods, and biometric identification for safe online tests can also be added to the framework. Personalised learning experiences, assessment integrity, and student engagement may all be further enhanced by these elements.

Future research should also investigate how the suggested framework might be integrated using standardised APIs with cloud-based services, trainer management systems, student enrolment platforms, and national educational information systems. To enable sustainable and successful deployment across various TVET institutions throughout Ethiopia, further efforts may concentrate on enhancing system performance, security, scalability, and multilingual support.

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APPENDICES

Appendix A: Sample Questionnaire

Questionnaire to be filled by TVET Trainers

Dear Respondent,

Thank you very much in advance for sparing time to fill in this questionnaire. The objective of the questionnaire is to gather first-hand information that will help in assessing the E-learning Approaches in TVET collages and identifying the gap and related issues. The study is conducted in Federal TVET institute ICT department I assure you that the responses will be kept confidential and used only for academic purposes. Thank you in advance for your time and genuine responses. If you require further briefing on the following contents, you can communicate using the following address:

Seblewengel Yebulgawerk

Phone number: +251933916243

Gmail: wengelseble3@gmail.com

Section A: demographics

Dear respondent, please respond to the following questions based on your demographic features using tick (Ö) mark and write an appropriate response for the open-ended question.

1. Sex:

☐ Female ☐Male

2. Age:

☐ <= 30 Years ☐41 – 50 Years

☐ 31 – 40 Years ☐>50 Years

3. Level of Education:

☐ Diploma ☐Masters

☐ BSc. Degree ☐above Master

4. Current position at the firm:

☐ Trainer ☐Trainee ☐Other please specify_____

Section B: Awareness (5-point Likert: 1 = Strongly Disagree, 5 = Strongly Agree)

- How affordable is internet access for you?(1-5)
- 'The current e-learning system is easy to use and supports interaction.
- Mobile learning would improve accessibility.

Appendix B: Interview Guide

1. What are the common features of the current E learning system?

2. How do you think infrastructure limitations affect the effectiveness of current e-learning systems?

3. Does the current e-learning system require continuous internet connectivity?

Appendix E: Ethical Clearance Letter

[Insert scanned copy of the Ethical Clearance Letter issued by the FDRE TVTI Research Ethics Committee or the host institution.]

Appendix F: Consent Form

Title of Study: assessing e-learning platforms in tvet colleges 'proposing a framework

Principal Investigator: seblewengel yebulgawerk, MSc Candidate, Department of Information Technology, FDRE TVTI.

Purpose: You are invited to participate in a research study whose purpose is to <briefly describe>. Your participation is entirely voluntary and you may withdraw at any time without consequence. Your responses will be kept confidential and used only for academic purposes.

I have read and understood the above information and I voluntarily agree to participate in this study.

Participant Name: _____ Signature: _____

Date: _____

Researcher Name: _____ Signature: _____

Date: _____

R.8 Sample Plagiarism and AI-Use Declaration

I, seblewengel yebulgawerk ID No. 192 hereby declare that this dissertation is entirely my own original work. All sources of information and ideas used from other authors or institutions have been duly acknowledged through proper citations and references following the <APA 5th edition / IEEE> style.

I further declare that I have used generative AI tools (such as ChatGPT, Claude, Gemini, Copilot, or similar) only for the following limited and disclosed purposes: language polishing, grammar checking, and idea exploration. No AI tool has been used to fabricate data, generate fictitious references, or produce the substantive intellectual content of this dissertation. Any AI-assisted output has been critically reviewed, verified, and revised by me, and the final dissertation reflects my own understanding, analysis, and conclusions.

I understand that academic dishonesty, including plagiarism and undisclosed AI use, may result in the cancellation of my degree per the regulations of FDRE TVTI.

Name: _____ Signature: _____ Date: _____

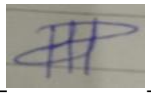
R.10 Supervisor Review Checklist

#	Review Item	Status (✓ / ✗)
1	Title is clear, focused, and aligned with the objectives	
2	Problem statement is well justified with evidence	
3	Research questions and objectives are SMART and aligned	
4	Literature review is current, critical, and identifies a clear gap	
5	Methodology is appropriate and reproducible	
6	System / model design is technically sound and well documented	
7	Implementation matches the design and is fully working	
8	Testing / evaluation is rigorous and results are convincing	
9	Discussion links the results back to objectives and prior work	
10	Conclusion, contributions, and recommendations are well stated	
11	References are complete and follow the required style	
12	Formatting (font, spacing, margins, captions) meets FDRE TVTI standards	
13	Plagiarism similarity report is acceptable	
14	AI-use declaration is included	
15	Language and academic style are of MSc-level quality	

Table R.2 Supervisor Review Checklist

Supervisor's Overall Recommendation (tick one):

- □ Approved for submission without revisions
- □ Approved for submission after minor revisions
- □ Major revisions required before submission
- □ Not yet ready for submission

Supervisor Name: _Dr.Hailay Beyene_ Signature: ________

Date: 09/28/2018