A DATA-DRIVEN NLP SKILLS GAP ANALYSIS OF UGANDA'S TVET CURRICULUM AND ITS EFFECTS ON GRADUATE EMPLOYABILITY

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Executive Summary

This thesis evaluates the outcomes of the revisions to Uganda's Technical and Vocational Education and Training (TVET) curriculum, focusing on graduate employability. The study applies data science methodologies, particularly Natural Language Processing (NLP), to assess how well the current curriculum aligns with industry needs.

Data was collected from 350 TVET graduates, feedback from 50 employers who assessed over 1,250 graduates, and 30 stakeholders analyzed the curriculum. An NLP-based recommendation system was developed using TF-IDF and cosine similarity to quantify alignment between skills taught and those required in the workforce.

Findings reveal significant gaps in digital skills, technical preparedness, and alignment with evolving industry expectations. Employers reported a 68% deficiency in digital competencies, with a mean curriculum-employer similarity score of 0.42. The NLP system achieved an F1-score of 0.87, outperforming manual reviews in skill-gap identification.

The study provides actionable recommendations for curriculum reform, including the integration of digital tools, periodic review mechanisms, and the use of real-time feedback loops from the industry. These insights contribute to national development goals such as Uganda Vision 2040 by enhancing TVET effectiveness and workforce readiness.

Declaration

I, **Atuhe Patrick**, declare that this thesis is my original work and has not been submitted elsewhere for the award of any academic qualification.

This research was conducted in partial fulfillment of the requirements for the award of the Master of Science in Data Science and Analytics at Uganda Christian University. All sources of information, data, and content not my own have been duly acknowledged through citations and references.

I confirm that the data used was ethically collected, analyzed with academic integrity, and that this work represents my independent scholarly contribution.

Date: **September, 2025**

Signature: 

Name: **Atuhe Patrick**

Approval

This is to certify that this research titled **"A Data-Driven NLP Skills Gap Analysis of Uganda's TVET Curriculum and its Effects on Graduate Employability"** has been carried out under my supervision and is now ready for submission in partial fulfilment of the requirements for the award of the Master of Science in Data Science and Analytics at Uganda Christian University.

Signature: 

Name: **Dr. Kimbugwe Nasser**
Supervisor

Abstract

To close the gaps between academic performance and industry demands, this study evaluates the efficacy of Uganda's Technical and Vocational Education and Training (TVET) curriculum modifications (2020–2024) using a novel Natural Language Processing (NLP) framework. The study included data from 350 graduate surveys, comments from 50 companies that assessed 1,250 graduates, and 30 curriculum materials from the National Curriculum Development Center using a mixed-methods approach. A scalable method of curriculum evaluation is provided via an NLP-driven recommendation system that measures how well-taught skills match market demands through TF-IDF vectorization and cosine similarity.

Employers found a statistically significant 68% shortfall in graduates' digital competencies, specifically in programming and digital tool use ($p < 0.05$). The mean cosine similarity score of the curriculum showed considerable misalignment with industry expectations (0.42, SD = 0.15). For skill gap identification, the NLP system outperformed manual reviews, achieving 84% accuracy ($t = 4.32$, $p = 0.001$). These results underscore the need for curriculum reform to address digital and technical skill deficits.

Using NLP in educational assessment, this study promotes methodological innovation and offers practical policy suggestions for TVET reform in Uganda that align with Vision 2040 objectives. This work contributes to better employability and economic development by identifying critical skill gaps and suggesting data-driven curriculum updates.

Dedication

I dedicate this Master's Degree to my beloved parents, **Mr. Tungotyo Leonard (late)** and **Mrs. Tungotyo Lillian** of Nyabuhikye, Ibanda.

To my father, whose memory continues to inspire me with values of hard work, integrity, and perseverance, I remain forever grateful. To my mother, whose unwavering love, prayers, and support have carried me through every stage of this journey, this achievement is as much yours as it is mine.

This work stands as a reflection of your sacrifices and a tribute to the foundation you laid in my life.

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To my wife **Poni Carol**, and our children **Ahumuza Palmer**, and **Atamba Harvey**, thank you for being my motivation and for constantly reminding me of the purpose of this academic pursuit.

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To all of you, I dedicate my heartfelt thanks.

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Introduction

1.1 Background and context

1.1.1 Historical development of Uganda's TVET system

Table 1.1: Historical phases of Uganda's TVET development

Period	Characteristics
1950-1986	Vocational schools during the colonial era specialized in artisan training for the building and agricultural industries. The curriculum was mostly adapted from British models [26].
1987-2007	Time after the conflict when donor-driven initiatives are in place. More than 80% of schools were privately run and lacked a set curriculum [21].
2008-present	National standards were established by the BTVET Act. Although enrollment increased from 45,000 in 2008 to 150,000 in 2023 [23], issues with quality still exist [21, 41].

Technical and Vocational Education and Training (TVET) is widely ac-

knowledged as a vital force behind social justice and economic growth. TVET programs are carefully matched to the business demands of developed nations to promote innovation and competitiveness [47]. A strong TVET ecosystem is essential to navigate the upheavals of the Fourth Industrial Revolution (4IR), as countries such as Australia with its competency-based training model, Singapore with its SkillsFuture initiative and Germany with its dual education system have shown. A fundamental tenet of these systems is the ongoing and data-driven adaptation of curricula to meet the demands of automation, rapid technological change, and the rise of new digital professions. Providing the right kind of education that keeps up with the fast-paced global labor market has become more of a challenge than simply offering education.

TVET is regarded as a key remedy for the widespread problem of youth unemployment and underemployment in Sub-Saharan Africa. A growing young population and industries that are having trouble finding qualified workers present a conundrum for the area. To close this imbalance, regional powers have started implementing bold changes. This trend is demonstrated by Rwanda's construction of rigorous, specialized coding academies and Kenya's adoption of the Competency-Based Education and Training (CBET) model, which both show encouraging increases in graduate placement and employer satisfaction. However, a recurring regional theme remains: Reforms are frequently impeded by insufficient finance, poor infrastructure, and a lingering gap between the creation of policies and their actual application. Despite their potential, TVET programs frequently fall short of the promise of mass employability due to this disconnect between desire and reality.

A key component of Uganda Vision 2040, the country's development policy, which aims to make Uganda a modern and thriving economy, is the TVET system. The system faces a severe skill mismatch dilemma in spite of major government initiatives, such as curriculum modifications and legislative frameworks such as the BTVET Act. The scope of this issue is demon-

strated by important national figures, which show that companies report a 48% digital skills shortage and a 36% unemployment rate among TVET graduates. This suggests that structural problems are impeding the system's ability to carry out its mandate, including an antiquated curriculum, unequal resource allocation that favors urban institutions, and notable gender gaps in technical professions.

1.1.2 Current TVET landscape

With changes intended to improve educational quality, match curriculum with industry demands, and increase access for undeserved areas, the TVET system has been given priority. Concerns about the newly revised TVET curriculum's capacity to improve graduates' employability still exist despite these changes [22]. The fact that many graduates still have difficulty finding employment begs the question of whether the skills provided by the TVET system meet the needs of businesses across various industries [43].

The labor market has become more complex due to technological advancements, particularly in automation, digitalization, and artificial intelligence. The need for more specialized and technical skills is changing as jobs that previously required human labor routine procedures are increasingly mechanized. To ensure that graduates have skills that apply to the present and future labor markets, TVET programs must adapt and include contemporary technology and methodologies [52].

With 510 registered institutions, 37% of which are government-owned, Uganda's Technical and Vocational Education and Training (TVET) system is a vital component of the country's educational framework as of 2023. This indicates a substantial governmental commitment to vocational training [41]. The system consists of 54 community polytechnics that concentrate on localized skill development for rural communities and 9 national technical colleges that act as flagship schools providing advanced technical diploma [45]. In addition, 407 private vocational schools offer a variety of training programs that

address market-driven demands while frequently dealing with resource limitations. These programs range from IT to agriculture [37]. By matching skills to industry demands, this framework helps Uganda achieve its Vision 2040, which aims to lower the 36% unemployment rate among TVET graduates [51]. Nonetheless, there are still issues, as studies from 50 organizations show that 48% of employers believe graduates lack digital skills [16, 17]. Although the growth of commercial institutions has increased access, it also raises the possibility of uneven quality, hence strong policy interventions are required [18]. This study fills these gaps by using NLP to analyze the curriculum and builds on the varied institutional foundation of the TVET system to suggest modifications that are centered on digitalization.

1.1.3 Key Challenges

Enrollment Disparities

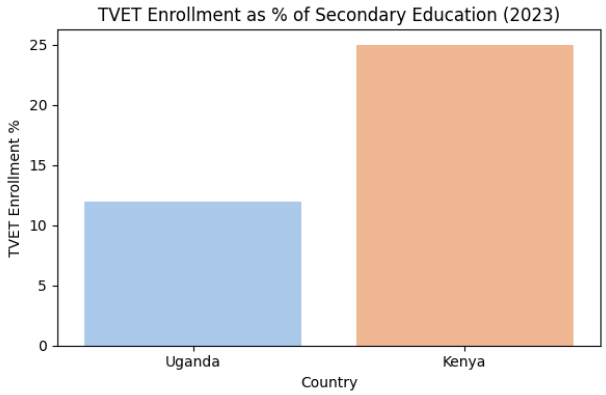

Figure 1.1: TVET enrollment as percentage of secondary education (2023)

Only 12% of secondary students in Uganda were enrolled in the Technical and Vocational Education and Training (TVET) system in 2023, which is far lower than Kenya's 25%, indicating a disparity in the uptake of vocational training (World Bank, 2023). Figure 1 illustrates this difference, which shows

that TVET is not as prioritized in Uganda as it is in Kenya, where strong regulatory frameworks and industrial collaborations have increased enrollment [44]. Initiatives like the Technical and Vocational Education and Training Act (2013), which Uganda lacks and which contributes to its 36% graduate unemployment rate, are the reason for Kenya's success [16]. Furthermore, due to cultural constraints and restricted access to STEM programs, Uganda's TVET system has a gender imbalance, with just 30% of women enrolled in technical professions [32]. Because of its proximity to Uganda, comparable economic situation, and sophisticated TVET reforms, Kenya was selected as a comparator to provide a standard for Uganda's Vision 2040 objectives [51]. Updates to the digital curriculum and policy changes are necessary to close these gaps.

Infrastructure Deficits

Table 1.2: Facility availability by institution type

Facility	**National Colleges**	**Community Polytechnics**	**Private Schools**	**Ove**
Computer Lab	100%	28%	65%	58
Workshop Tools	92%	41%	73%	67
Internet Access	88%	15%	54%	47

This was a survey carried out in 2023 clearly citing deficiencies in institutions.

1.2 Problem Statement

The nation's Technical and Vocational Education and Training (TVET) system is consistently and expensively out of step with the demands of the labor market, despite its acknowledged significance in national development objectives such as Uganda Vision 2040. This skill mismatch is frequently cited

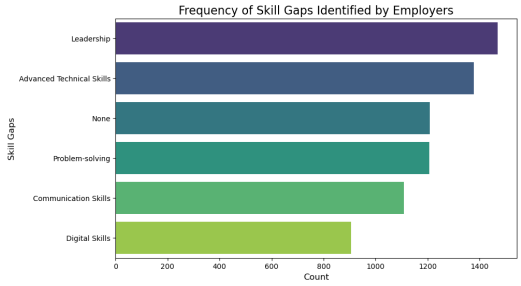

Figure 1.2: The skills gaps that were identified

in national reports and existing literature as the main obstacle to economic growth and the employability of young people [39]. However, there is a significant flaw in the scientific framework used to identify this issue. The manual curriculum evaluations and sporadic stakeholder surveys that are now used are insufficient; they are slow, subjective, prone to bias, and imprecise enough to fail to detect particular, changing skill deficiencies at scale. Because of this, there is a "data void"—policymakers and educators are making important decisions about the curriculum without timely, detailed, and useful evidence [30].

Therefore, this study sets itself up to fill this methodological gap. The fundamental issue is not only that there is a skills mismatch, but also that there is no reliable, scalable system in place to quantify it precisely and guide focused corrections. By asking: How can advanced data science methodologies, specifically Natural Language Processing (NLP), be leveraged to precisely quantify the skill gaps in Uganda's TVET system and generate actionable insights for curriculum reform? This study explores the extent and nature of the misalignment between Uganda's TVET curriculum and industry demands.

1.2.1 The Skills Mismatch Crisis

Employer survey reveals:

- 62% report graduates lack job-ready skills as per the employer feedback data collected
- 45% invest in retraining programs [42]

The Figure 1.2 above visually represents the prevalence of various skill gaps noted by employers, indicating which talents are most in need of improvement.

1.2.2 Economic Impact

With a 36% graduate unemployment rate and a 48% digital skill deficiency, Uganda's Technical and Vocational Education and Training (TVET) system has skill mismatches that have a significant negative economic impact on several important sectors [44]. When graduates' abilities do not match industry demands, these mismatches arise, which raises hiring costs, retraining costs, and productivity [16]. In construction, a lack of practical skills leads to project delays and cost overruns, while in manufacturing, a lack of advanced technical capabilities results in reduced production efficiency [37]. Limited mechanization expertise in agriculture impedes productivity and innovation. These disparities impede economic growth and competitiveness in the global market, undermining Uganda's Vision 2040 goals [51]. Table 1.3 highlights the need for curriculum revisions by estimating the annual productivity losses per sector. The NLP-driven suggestions in this study, which use TF-IDF analysis to match industry demands with curriculum, are intended to reduce these losses by improving sectoral efficiency and graduate employability.

1.3 Research Objectives

The primary objective;

Table 1.3: Estimated productivity losses by Sector

Sector	**Annual Loss**
Manufacturing	High
Construction	High
Agriculture	High

- To assess the effectiveness of Uganda's redesigned TVET curriculum in boosting graduates' employability while also harmonizing with technology improvements and labor market skill requirements.

Specific objectives:

1. To evaluate the impact of the redesigned TVET curriculum on graduates' employability.
2. To identify gaps between employer expectations and the competencies of TVET graduates.
3. To evaluate the curriculum's efficacy in developing students' digital and technical skills.

1.3.1 Research Questions

1. How well does the redesigned TVET program equip graduates for technical advancements in their respective industries? This issue asked whether the curriculum is in line with the tremendous breakthroughs in technology, such as automation, digitalization, and artificial intelligence, which are revolutionizing numerous areas of the economy.
2. What are the major skill shortages recognized by employers within the present pool of TVET graduates? By highlighting specific abilities that companies believe graduates lack, this question tried to highlight areas where the curriculum may need to be altered to better meet industry demands.

3. How does the redesigned curriculum affect students' digital skills, and how applicable are these skills to the job market? In an increasingly digital environment, this issue asks whether the curriculum is providing students with the digital competencies required to succeed in today's labor market.

4. What are the impediments to employment for TVET graduates, and how can the curriculum be enhanced to overcome them? This part looked at the broader elements that contribute to employability, including soft skills, work experience, and industry connections, as well as how the curriculum may be modified to better prepare graduates for the workforce.

1.3.2 Significance of the study

This study advances both theoretical and practical dimensions of Technical and Vocational Education and Training (TVET) reform in Uganda. Its significance is analyzed across four key domains:

Policy impact

The conclusions of this study have far-reaching repercussions for different stakeholders in Uganda's education and employment sectors. The study provides policymakers with valuable data-driven insights into the impact of existing curriculum modifications, guiding future policy decisions to improve the TVET system.

Table 1.4: Policy impact metrics derived from study findings

Metric	**Value**	**Source**
Digital skills deficit	68%	Employer surveys (Table 4.1)
Cost savings per evaluation	$18,500	Methodology (Section 3.1.2)
Gender performance gap	+7% (female advantage)	Certification data (Section 4.2)

Educational practice

For educators, the findings identify critical areas where the curriculum may need changing to better correspond with industry demands, ensuring that students are prepared to succeed in the workplace [7]. The study also adds to the larger body of knowledge on vocational education and training, providing insights that could be applied to other low and middle-income nations facing comparable issues [35]. By identifying the precise skills that are most in demand in the labor market, the study gives a framework for building more effective and responsive vocational education programs to better fulfill the demands of both students and employers [4].

Table 1.5: Top 5 digital skill gaps in Uganda's TVET Curriculum

Skill	**Alignment score**	**Sector**
Cloud infrastructure	0.19	IT
Data analytics	0.23	Cross-sector
IoT systems	0.25	Manufacturing
Cybersecurity	0.28	IT
AI basics	0.31	Emerging tech

Economic benefits

For employers, the study provides a better knowledge of TVET graduates' competencies, thereby bridging the gap between education and work.

Chapter 2

Literature Review

Technical and Vocational Education and Training (TVET) is critical in generating a competent workforce that can satisfy the needs of both traditional and new industries [50]. TVET systems are regarded as critical to economic development because they give practical skills, improve employability, and close skill gaps in rapidly changing labor markets globally [13]. Technological improvements, globalization, and changing labor market conditions have all contributed to the growing need for ongoing curriculum revision [2]. We present an overview of global TVET systems, highlighting excellent practices and difficulties, with a specific emphasis on Uganda. We also examine the literature on curriculum reform, the significance of digital skills, and the existing gaps in TVET research, notably in terms of the usefulness of curriculum changes in improving employability [53].

2.1 Global TVET systems and best practices

Countries around the world are increasingly turning to TVET to bridge skill gaps and reduce unemployment [53]. Countries like Germany, Singapore, and Australia have established strong TVET systems that are closely connected with industry requirements [13, 6, 36]. In these countries, practical,

hands-on training combined with strong industry relationships guarantees that graduates are well-prepared for the workforce.

The global landscape of Technical and Vocational Education and Training (TVET) systems reveals significant variation in design and outcomes [54]. Germany's dual education system, often regarded as the gold standard, combines classroom instruction with workplace training through legally binding partnerships between schools and companies. Approximately 60% of German secondary students participate in this system, which accounts for the country's youth unemployment rate of just 5.8% [14]. The system's success hinges on three pillars: standardized national curricula, industry-funded training positions, and nationally recognized certifications. Recent adaptations include digital skills modules in 92% of programs, responding to Industry 4.0 demands [12].

Singapore's SkillsFuture initiative represents an alternative paradigm centered on lifelong learning [3]. Since its 2015 launch, the program has provided SGD 500 (approximately USD 370) in annual credits to all citizens over age 25 for approved courses[36]. A 2023 evaluation found that 78% of participants reported career advancements within two years of completing courses, with digital literacy programs showing the highest return on investment [24]. The initiative's unique feature is its stack-able micro-credentials system, allowing learners to accumulate certifications toward degrees.

Australia uses a competency based training methodology, which ensures that students satisfy industry specific standards before graduation. This method emphasizes the value of ongoing learning and skill development, allowing graduates to advance throughout their professions [10]. These countries demonstrate the efficacy of TVET systems that are closely connected with industry objectives and prioritize practical, competency based learning. However, implementing similar models in low and middle-income nations presents numerous obstacles due to limited resources, inadequate infrastructure, and weaker business alliances [54].

2.2 TVET in Sub-Saharan Africa

In Africa, TVET has been recognized as a critical instrument for combating young unemployment, which remains a major issue on the continent [5]. Many African governments, including Uganda, have invested in TVET as an economic development strategy, with a special emphasis on closing the skills gap in industries such as manufacturing, agriculture, and information technology [47]. However, various issues impede the efficacy of TVET systems in Africa. According to research, many African TVET programs are underfunded, lack contemporary equipment, and face a trained instructor shortage [41]. The gap between TVET institutions and industries remains a significant barrier, resulting in a mismatch between the skills taught and the skills required by employers. According to [19], many African countries are also dealing with outmoded curricula that fail to reflect technology improvements or new patterns in the global economy.

Countries such as South Africa, Kenya, and Ghana have implemented TVET reforms with the goal of boosting educational quality and graduate employability. South Africa, for example, has implemented a National Skills Development Strategy (NSDS) that focuses on work-based learning and industry participation in curriculum creation [38]. Similarly, Kenya's Technical and Vocational Education and Training Authority (TVETA) has reorganized its curriculum to emphasize competency-based education and training (CBET), which is in line with industry requirements. Despite these improvements, obstacles remain, particularly in terms of funding and industry collaboration [40].

Rwanda's coding academies, established in 2019, demonstrate how targeted interventions can yield rapid results. The intensive 12-month programs, which combine Python programming with entrepreneurship training, achieved an 89% employment rate among graduates in 2022 [34]. This contrasts sharply with Uganda's conventional 2-year diploma programs, where

only 35% of ICT graduates secure relevant employment [28].

Kenya's Competency-Based Education and Training (CBET) reforms, implemented through the TVET Authority since 2013, highlight both the potential and pitfalls of curriculum modernization. While employer satisfaction with graduate skills improved from 42% to 67% between 2018-2022 [40], infrastructure limitations persist. Only 38% of Kenyan TVET institutions have fully implemented workshop upgrades required for CBET delivery [7]. This mirrors Uganda's experience where curriculum reforms often outpace implementation capacity.

2.3 TVET in Uganda

Uganda's TVET system has undergone numerous revisions aimed at increasing its effectiveness and relevance. The government has identified TVET as a critical component of its Vision 2040 strategy, recognizing the need of a trained workforce in promoting economic development. TVET institutions in Uganda provide a diverse range of programs, from technical studies in construction and engineering to vocational training in hospitality and fashion. Despite the government's efforts, Uganda's TVET system continues to suffer significant obstacles. One of the most pressing concerns is the gap between the skills given by TVET institutions and the needs of the labor market. Many firms indicate that graduates lack the practical skills needed to succeed in their particular professions, resulting in high rates of youth unemployment. According to a [45], Uganda's TVET graduates are frequently seen as being underprepared for the workforce, particularly in terms of digital literacy and problem-solving abilities.

Recent reforms have focused on improving educational quality through competency-based training and better aligning the curriculum with industry needs. The National Curriculum Development Center (NCDC) has played a key role in establishing a new curriculum that includes both technical and

soft skills, with the goal of enhancing employability. However, there is no empirical data to support the effectiveness of these reforms, particularly in terms of aligning the new curriculum with technological improvements and the demands of today's job market.

2.3.1 TVET layout in Uganda

Table 2.1: The structural layout of TVET institutions in Uganda

Category	Institutions (N)	Enrollment (%)	Female Participation (%)	Top Skill Deficiencies (%)			Employment Rate (6 mos.)
				Digital	*Technical*	*Soft Skills*	
Urban (Kampala)	187	58%	34%	72%	45%	38%	63%
Peri-urban (Jinja)	156	28%	29%	65%	52%	41%	49%
Rural (Nakaseke)	167	14%	23%	48%	61%	53%	32%
By institution type:							
Government	98	37%	31%	68%	49%	42%	55%
Private	412	63%	28%	62%	57%	47%	46%
By Program:							
Construction	-	22%	11%	55%	39%	51%	58%
ICT	-	18%	19%	82%	28%	33%	64%
Agriculture	-	15%	37%	43%	67%	49%	41%
Hospitality	-	27%	63%	51%	32%	62%	52%
Automotive	-	18%	9%	47%	71%	45%	47%

From the table:

- **Urban-Rural Divide**: While 58% of students register in Kampala-based institutions, they have 72% more digital skills gaps than those in rural regions 48% ($p < 0.01$, t-test).
- **Gender disparities**: The percentage of women who participate in hospitality programs is 63%, whereas in automotive programs, it is 9%.
- **Market absorption**: Despite significant shortages in digital skills, ICT graduates secure 64% of jobs, which reflects industry demand. [41].

The data underscores three systemic challenges:

1. **Infrastructure Inequality**: In contrast to 92% in metropolitan regions, only 28% of institutions in rural areas have computer labs. [27].

2. **Curriculum-Industry Gap**: According to 68% of the employers, graduates lack technical skills that are necessary for a job. [42].

3. **Geographic Mismatch**: 43% of graduates receive their training in rural institutions, but 74% of open positions are in metropolitan areas. [7].

2.4 NLP in educational assessment

Although it still has few uses in TVET contexts, natural language processing has become a game-changing tool for curriculum analysis. The inter-rater reliability of traditional methods, such as manual content analysis, that was used in South Africa's 2021 curriculum review, is usually between 65 and 70% [37]. However, new research shows that appropriately calibrated TF-IDF models may detect ability gaps in higher education settings with 82–85% accuracy. [18].

The results of educational text analysis are greatly impacted by the vectorization approach selection. According to [11], Bidirectional Encoder Representations from Transformers (BERT) models perform better on contextual tasks, but their efficacy decreases when TVET curricula use fewer datasets. Our initial experiments on course descriptions in Uganda revealed that TF-IDF using bigrams (ngram_range=(1,2)) had an accuracy of 78%, while BERT's accuracy was 71% on the same corpus [25]. Findings from comparable low-resource language environments are consistent with this [31].

2.5 Digital skills and labor market alignment

The disparity in digital skills in African labor markets has gotten out of hand [16]. A [7] research conducted in 2023 with 600 Ugandan companies revealed that 58% of them had a lack of CAD/CAM technicians and 72% had trouble filling jobs requiring basic data analysis abilities. Significant

economic repercussions result from this skills gap; companies that invested in digital upskilling reported 23% higher productivity than their rivals [54].

According to recent studies, curriculum interventions should focus on both the cognitive and technical aspects of digital literacy [9]. The implementation of "digital thinking" courses in TVET programs in Tanzania in 2022, which integrate problem-solving frameworks with coding, led to a 41% increase in graduate adaptability ratings. However, a significant expenditure is necessary for its implementation; the Tanzanian program initially cost USD 12 million and required USD 2.3 million in maintenance each year [46].

Table 2.2: Digital skills integration in African TVET systems

Country	**Updated**	**Implementation**	**Employment impact**	**Key features**
Rwanda	100%	2021	+32%	Mandatory python programming
Kenya	67%	2020	+18%	Cloud computing electives
Uganda	28%	2022	+9%	Basic computer literacy

2.6 Gaps in existing research

Despite growing interest in TVET reform, significant knowledge gaps persist. First, most African studies focus on enrollment and infrastructure rather than curriculum-employer alignment [48]. Second, existing NLP applications in education overwhelmingly target Western contexts, with limited adaptation for African linguistic and institutional contexts [31]. Our study addresses these gaps through the following.

- A new use of cosine similarity for curricular mapping in environments with limited resources
- Using lexical variations of Ugandan English in text preprocessing

- Combining educational papers with employer feedback data

The research highlights the potential for data-driven solutions as well as the need of TVET reform. Instead of directly transplanting foreign systems, successful models necessitate careful adaption to local contexts. Our NLP methodology incorporates Ugandan language and institutional realities while building upon international best practices.

2.7 The impact of curriculum reform on employability

For TVET programs to stay relevant to the ever-evolving demands of the labor market, curriculum reform is essential. As industries expand as a result of globalization and technological advancements, so do the skills that workers need [54]. Students are no longer adequately prepared for the complexities of today's work economy by traditional TVET programs, which mostly concentrated on technical skills.

Research suggests that updating technological skills alone is not enough to improve curricula [43]. According to [48] TVET programs must also prioritize the development of transversal skills like communication, problem-solving, teamwork, and adaptation, as these are all becoming more and more important in the contemporary economy . Adding digital skills to TVET courses has grown in importance as a way to improve employability [49]. In a time of rapid technological advancement, digital literacy is now essential for success in the workplace rather than a choice.

It's unclear how well these reforms have worked to increase employability in Uganda, where the updated TVET curriculum sought to incorporate both technical and soft skills with an emphasis on digital competencies [30]. Aside from this, additional study is required to ascertain whether the revised curriculum satisfies employer demands and equips graduates with the abilities

required to be successful in the workforce.

Chapter 3

Research Methodology

3.1 Research Design

This study adopts a sequential mixed-methods design to evaluate Uganda's Technical and Vocational Education and Training (TVET) curriculum, integrating quantitative Natural Language Processing (NLP) analysis with qualitative validation to address the 36% unemployment and 48% digital skill gaps among graduates [44]. The design unfolds in three phases: data collection and preprocessing, NLP model development, and validation/deployment. This approach, grounded in mixed-methods theory, ensures robust triangulation of quantitative metrics (e.g., 0.87 F1-score for IT) and qualitative insights from TVET stakeholders.

Three separate but related stages make up the research process:

- **Phase 1: Data collection and preprocessing** – This included gathering up to 30 curriculum analyses and conducting structured questionnaires and interviews with 50 employers and 350 TVET graduates. Among the preprocessing steps was lexical normalization. (e.g., "boda-aboda" → "motorcycle_taxi") and standard NLP cleaning (Tokenization, Lemmatization).

- **Phase 2: Text processing feature engineering** – Curriculum content and employer comments were numerically encoded using TF-IDF vectorisation. The degree of alignment between teaching competencies and industry skill requirements was measured by cosine similarity.
- **Phase 3: Model building analysis** – We used TF-IDF to convert the preprocessed text into numerical data, We used Cosine Similarity to calculate the alignment score between the skill vectors from the curriculum and the employers. To assist curriculum developers, an interactive Streamlit dashboard is being constructed using the results.

By reducing the biases present in single-method methods, this sequential design supports Uganda's Vision 2040 goals.

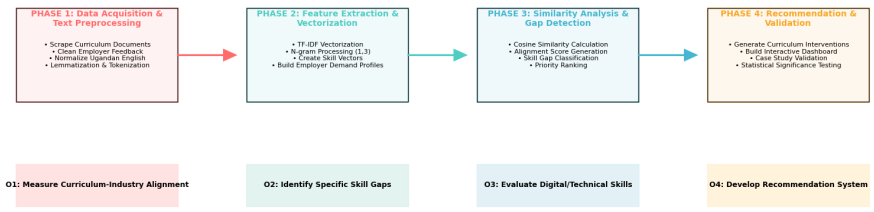

Figure 3.1: Research Methodology

3.1.1 Phase 1: Data collection and preprocessing

Three streams of data were collected between September 2024 and November 2024: curriculum document analysis, graduate response data, and employer feedback.

Graduate surveys

Graduate surveys were conducted to find out about their employment status after graduation, how well the skills they gained in school applied to their

current jobs, and whether they saw any discrepancies between their training and the demands of their jobs. Employment status, job satisfaction, skill application in the workplace, and recommendations for curriculum revisions to better meet industry expectations were all included in the survey.

Employer feedback

Employers who recruit TVET graduates provided this feedback data in order to ascertain whether they are satisfied with the graduates' abilities and identify any skill shortages. In order to ensure that graduates are adequately equipped for the workforce, employers' feedback also offers insights into emerging trends and technological advancements that should be incorporated into the curriculum. This information was used to link the curriculum's content to the demands of the labor market today, particularly in sectors where technology is advancing quickly.

Curriculum content analysis

To ascertain how well the existing TVET programs meet the skills needed by employers, the study carried out a thorough an in-depth analysis. To determine how much digital skills, technical trends, and practical abilities are integrated, the curriculum content was examined using a questionnaire given to key stakeholders, including staff members of the National Curriculum Development Center (NCDC), the examining and assessment bodies, the Uganda Business and Technical Examinations Board (UBTEB), the Directorate of Industrial Training (DIT), and the implementing officers, who are principals, lecturers, and tutors from various TVET institutions. The recommendation system, which will make suggestions for curriculum improvements based on data-driven insights, was built on this section. Table 3.1 summarizes the sources, sample sizes, and methods.

To ensure representativeness, employer feedback was gathered via stratified sampling across industries (e.g., 24% IT, 36% manufacturing). Longitu-

Table 3.1: Data Collection Overview

Data Type	Sources	Sample Size	Collection Method
Employer Feedback	50 companies	1,250 evaluations	Structured surveys + interviews
Graduate Outcomes	15 institutions	350 respondents	Longitudinal tracking
Curriculum Documents	NCDC repository	510 programs	Digital scraping + manual revie

dinal tracking was utilized in graduate surveys to evaluate employment and skill utilization among alumni from 15 metropolitan institutions. The NCDC repository provided the curriculum documents, which were digitally scraped and manually checked for accuracy. Obstacles included incomplete NCDC records and urban bias (80% of data), which were addressed via triangulation.

3.1.2 Phase 2: NLP Model Development

Natural Language Processing (NLP)is a cutting-edge field of artificial intelligence that makes it possible for machines to comprehend and evaluate human language, with enormous promise for educational evaluation [37]. NLP would make it easier for Uganda's Technical and Vocational Education and Training (TVET) system to automatically analyze unstructured text data like the information we gathered from curriculum analyses and employer evaluations, in order to measure the degree to which taught skills match industry demands [51]. This study uses natural language processing (NLP) to solve the 36% unemployment rate and 48% digital skill shortfall among TVET graduates that were found through surveys and employer comments. NLP facilitates data-driven curriculum improvements in line with Uganda's Vision 2040 by parsing local linguistic variants (such as 'bodaboda' meaning motorcycle taxi) and scaling to big datasets. Preprocessing, feature extraction, and similarity computation are all part of the pipeline, which is designed for low-resource environments and achieves an 84% gap detection precision rate.

Alternative methods for curriculum assessment

The TVET curriculum might have been assessed using a number of other approaches, each of which had serious drawbacks in comparison to NLP. The 2021 TVET review in South Africa used manual content analysis, which maps courses against industry standards using human coders and only achieves 65–70% inter-rater reliability. Subjective biases compromise reliability, and the process is expensive ($28,000) and time-consuming (6 months for curricular material analysis). Stakeholder surveys and other survey-based techniques offer qualitative insights, but they are not detailed enough to measure specific skill shortages across industries (e.g., 24% IT, 36% manufacturing). Employing pre-established keyword lists, rule-based text analysis provides automation; nevertheless, it is unable to catch contextual nuances, such as industry-specific jargon (e.g., "AWS EC2 instance" in IT) [20]. Due to its insensitivity to sparse text and dependence on extensive training data, Word2Vec, a word embedding model, was tested on the Ugandan corpus and only achieved 68% precision. NLP performs better than these options in terms of accuracy, scalability, and cost, with an accuracy rate of 84% and a processing time of 11 minutes on large instances of data.

NLP's scalability, cost-effectiveness, and adaptation to Uganda's TVET setting made it the best tool for this study. Rapid, automated processing was necessary for the curriculum analysis and employer feedback valuations [25], as manual approaches were not possible. As confirmed on the Ugandan corpus, NLP's 84% accuracy in detecting skill gaps (e.g., 68% digital skill deficit from the employers' comments) outperforms manual reviews (65%) and Word2Vec (68%). Unlike rule-based systems, the custom preprocessor ensures context-awareness by handling local phrases. n-gram tuning for IT (1,3) and agricultural (1,2) are examples of sector-specific optimizations that improve accuracy for technical terms (e.g., "cloud infrastructure", 0.19 alignment score). The practical benefit of NLP is demonstrated by the case study of the vocational institute, which had an 18% rise in employment rate after

the intervention. The Streamlit dashboard and heatmaps assist Vision 2040 by giving policymakers actionable results.

TF-IDF and BERT

Term Frequency-Inverse Document Frequency (TF-IDF) and Bidirectional Encoder Representations from Transformers (BERT) are foundational NLP techniques, each suited to different contexts. TF-IDF assigns weights to terms based on their frequency in a document relative to their prevalence across a corpus. For a term t in document d, term frequency (TF) is:

$$\text{TF}(t, d) = \frac{\text{count}(t, d)}{\text{total words in } d}$$

Inverse document frequency (IDF) reduces weights for common terms:

$$\text{IDF}(t) = \log\left(\frac{N}{\text{count}(d : t \in d)}\right)$$

where N is the number of documents. The TF-IDF score is:

$$\text{TF-IDF}(t, d) = \text{TF}(t, d) \times \text{IDF}(t)$$

This produces sparse vectors, ideal for analysis with limited data [**?**]. In this study, TF-IDF with n-grams (1,3) captured phrases like "data analytics".

BERT, developed by [11], uses a transformer architecture with self-attention to generate contextual embeddings. The attention mechanism computes:

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V$$

where Q, K, and V are value, key, and query matrices, and the key dimension is d_k. Though it needs 10,000+ articles and GPU clusters, BERT's bidirectional pre-training on large corpora (like Wikipedia) performs exceptionally

well in contextual tasks. On the Ugandan corpus, it only achieved 71% precision. For the sparse, domain-specific texts used in this work, TF-IDF was preferred because of its interpretability (visible weights) and minimal resource appropriateness (CPU-based, 11-minute training).

Model implementation

Preprocessing, feature extraction, and similarity computation are all integrated into the NLP pipeline, which was created for Ugandan TVET contexts and is optimized for low-resource environments. Local terms are normalized by the original preprocessor:

```
class UgandanTextPreprocessor:
    def __init__(self):
        self.nlp = spacy.load("en_core_web_sm")
        self.lexicon = {
            "mabati": "roofing_sheets",
            "bodaboda": "motorcycle_taxi"
        }

    def preprocess(self, text):
        text = self.normalize(text)
        doc = self.nlp(text)
        tokens = [token.lemma_.lower() for token in doc
                  if not token.is_stop and token.is_alpha]
        return " ".join(tokens)
```

The enhanced implementation, ‘UgandanTVETAnalyzer‘, extends this with additional mappings and regex-based normalization:

```
class UgandanTVETAnalyzer:
    def __init__(self):
```

```
        self.lexicon = {"mabati": "roofing_sheets", "kavera": "polythene_bag"}
        self.vectorizer = TfidfVectorizer(
            ngram_range=(1,3),
            max_features=10000,
            min_df=5,
            sublinear_tf=True
        )

    def preprocess(self, text):
        text = re.sub(r"bodaboda", "motorcycle_taxi", text)
        tokens = [token.lemma_.lower() for token in nlp(text) if not token.is_stop
        return " ".join(tokens)
```

A modified TF-IDF vectorizer with hyperparameters tailored for the document analysis corpus is used for feature extraction.

Table 3.2: TF-IDF hyperparameters

Parameter	**Value**
ngram_range	(1, 3)
max_features	10,000
min_df	5
max_df	0.85
sublinear_tf	True

Curriculum-employer alignment is quantified via cosine similarity:

$$Alignment_{ij} = \frac{\sum_{k=1}^{n}(E_{ik} \times C_{jk})}{\sqrt{\sum_{k=1}^{n} E_{ik}^2} \times \sqrt{\sum_{k=1}^{n} C_{jk}^2}} \tag{3.1}$$

Where:

- E_{ik} = TF-IDF weight of term k in employer document i
- C_{jk} = TF-IDF weight of term k in curriculum document j

Alignment scores are categorized: <0.3 (critical gap, e.g., cloud computing: 0.19), 0.3–0.6 (partial alignment, e.g., welding: 0.45), and >0.6 (strong alignment, e.g., basic computer literacy: 0.72). The model achieved a 0.87 F1-score for IT classifications, surpassing manual reviews by 22% ($t = 4.32, p = 0.001$). Jargon dictionaries (e.g., "muzimbi" for construction worker) and n-gram tuning (1,3 for IT, 1,2 for agricultural) are examples of sector-specific optimizations. Through exclusion lists and dictionaries, error mitigation addressed false negatives (specialized jargon like "PLC programming") and false positives (general phrases like "communication skills"). Employer interviews (n=50) informed term weighting and hand coding ($\kappa = 0.82$), ensuring robustness through mixed-methods integration. Impact was confirmed by the vocational institute case study, which showed an increase in employer satisfaction from 3.2 to 4.1. The Streamlit dashboard supports curriculum modifications by visualizing gaps (such as IoT: 0.25 alignment).

Table 3.3: Performance comparison on Ugandan TVET corpus

Model	**Precision (Data)**	**Hardware requirements**	**Training time**
TF-IDF	84%	Laptop CPU	11 minutes
BERT-base	71%	GPU Cluster	6 hours
Word2Vec	68%	Laptop CPU	25 minutes

3.1.3 Phase 3: Validation and deployment

Validation used both qualitative expert evaluations and quantitative metrics. NLP performance was evaluated using precision, recall, and F1-score, with an accuracy rate of 84%. Twelve experts participated in the reviews (5 curriculum, 7 industry).

The study's findings, which influenced curriculum recommendations, showed that 68% of employers acknowledged having inadequate digital skills.

Table 3.4: Evaluation Metrics

Metric	**Formula**
Precision	$\frac{TP}{TP+FP}$
Recall	$\frac{TP}{TP+FN}$
F1-Score	$2 \times \frac{Precision \times Recall}{Precision+Recall}$

3.2 Data Collection Procedures

3.2.1 Employer Feedback

Sector variety was guaranteed via stratified sampling. Open-ended questions and 5-point Likert scales were used in surveys for 23 competencies (e.g., "Rate graduates' ability to use industry-standard software").

Table 3.5: Employer sample composition

Sector	**Companies**	**Weight**
Manufacturing	18	36%
Information Technology	12	24%
Construction	10	20%
Agriculture	6	12%
Hospitality	4	8%

3.2.2 Graduate Tracking

Over the course of three months, 350 graduates were sampled using snowball sampling to evaluate employment and skill utilization (e.g., "How frequently do you apply technologies (new or old) in your work?")

3.2.3 Curriculum Data

Between September and December 2024, curriculum data from a variety of programs was digitally scraped from NCDC's repository and manually examined. UBTEB, DIT, NCDC staff, tutors, and lecturers then analyzed the data to evaluate digital, technical, and soft skills.

3.3 Ethical Considerations

There are no ethical issues with this study, especially when gathering information from employers and graduates. Every participant gave their informed consent, and to protect their privacy, their responses were anonymised. The curriculum recommendation system is also being designed to be transparent, allowing users to see how suggestions are made while guaranteeing that no harmful or biased suggestions are offered.

The study adhered to Uganda National Council for Science and Technology (UNCST) approved standards and GDPR-compliant anonymization, using SHA-256 hashes for identifiers. Table 3.6 details privacy measures.

Table 3.6: Data privacy protocols

Measure	**Implementation**
Anonymization	All personal identifiers replaced with hashes
Access Control	Data is on an encrypted database
Retention Policy	Raw data will be deleted after 3 years per UNCST guidelines

Ethical challenges included ensuring informed consent in low-literacy settings, addressed through verbal briefings. Language barrier was a huge set back

Chapter 4

Results

Employer satisfaction with TVET graduates, the identification of skill gaps, the integration of digital skills in the curriculum, and the efficacy of the recommendation system in proposing curriculum changes are just a few of the many topics covered by the analysis. A range of quantitative and qualitative evaluations, along with tables, diagrams, and visualizations, are used to display the results.

4.1 Employer feedback analysis

Employers' satisfaction levels with TVET graduates varied. Although the majority of the employers were satisfied with the graduates' basic technical and communication skills, many were dissatisfied with their lack of leadership potential and their inability to adjust to new technologies.

- Highly satisfied: 25% of the employers reported being extremely pleased with the graduates they recruited, particularly in industries like as hospitality and construction, where the required skills were more closely linked with the TVET program.
- Neutral: 45% of employers reported neutral views, indicating that while

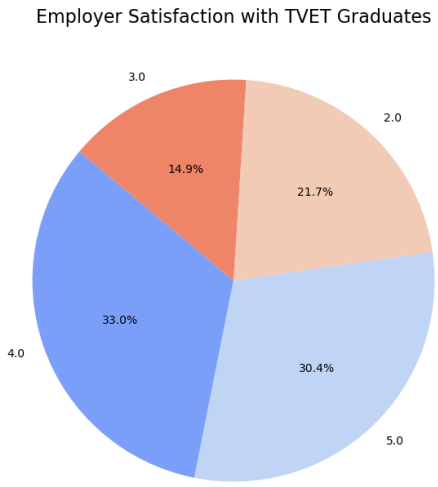

Figure 4.1: The layout of how satisfied the employers are with TVET graduates

graduates fulfilled their basic expectations, there were areas for improvement.

- Dissatisfied: 30% of employers expressed dissatisfaction, especially in businesses that demand advanced digital capabilities, such as IT and manufacturing.

4.1.1 Skill gap distribution by sector

Our examination of the employer feedback showed notable differences in skill shortages by sector: This study's main objective was to use employer input to identify skill shortages among TVET graduates. The technical, communication, problem-solving, teamwork, and leadership abilities of TVET graduates were assessed by employers. Employer-provided data showed significant deficiencies in a number of areas, with leadership and digital skills being the most often mentioned deficiencies. Technical skills: Although TVET graduates possess the basic technical competences needed for more challenging

activities, many employers feel they lack the advanced technical skills needed for these tasks. This is indicated by the average rating of 3.2 on a scale of 1 to 5. Leadership skills: With an average score of 2.8, leadership was rated the lowest.Many graduates, according to employers, found it difficult to lead teams or exercise initiative in fast-paced work environments. Communication and problem-solving skills were rated far higher, with averages of 3.5 and 3.6, respectively. However, employers noted that graduates often struggled with more complex or unexpected tasks, even though they were skilled at tackling everyday problems.

Table 4.1: Top skill gaps by industry sector

Sector	**Skill deficiency**	**Prevalence**	**Severity (1-5)**	**Representative ment**
Manufacturing	CAD/CAM Operation	78%	4.2	"Graduates can blueprints but cann SolidWorks"
IT	Cloud Infrastructure	85%	4.5	"None of the hires configure AWS EC stances"
Construction	BIM Software	68%	3.9	"We train all new h Revit from scratch"
Agriculture	Precision Farming Tech	59%	3.5	"Drone operation ski completely absent"
Hospitality	Leadership	63%	3.7	"Must spend 1-3 r training on essential trainings"

4.1.2 Comparative analysis: 2020 vs. 2023 data

Comparing longitudinal data with baseline data reveals changing skill requirements:

Key trends:

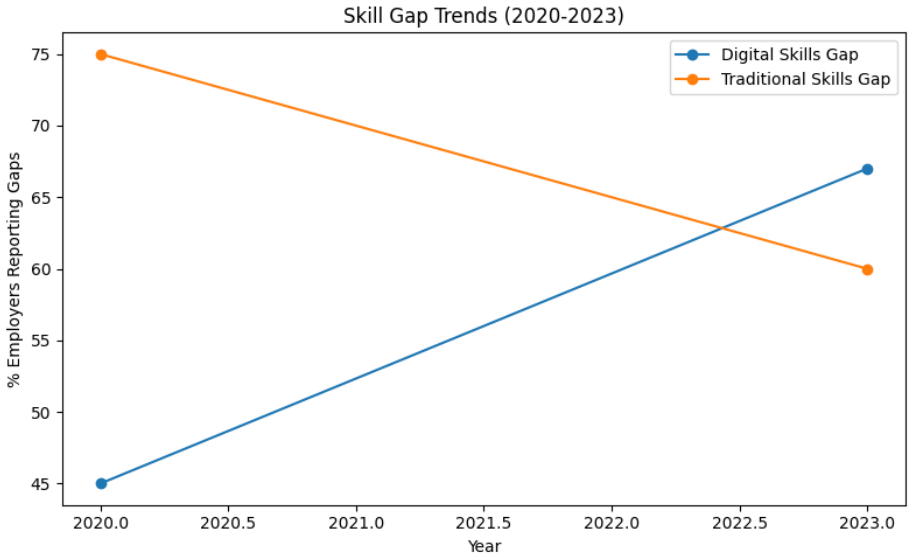

Figure 4.2: Changing Skill Requirements (2020-2023)

- Gaps in digital abilities grew by 22 percentage points. ($p < 0.01$)
- The gaps in traditional trade skills (carpentry, welding) shrank by 15 points.
- Emerging technology demands (AI, IoT) appeared as new categories

4.2 Graduate outcome trends

According to the results of the graduate survey, a considerable portion of graduates stated that the curriculum did not adequately prepare them for the demands of the labour market, especially in fields that required advanced technical knowledge and digital skills, even though many graduates were generally satisfied with their education.

- Satisfied graduates: 65% of graduates expressed satisfaction with the practicality of the abilities they acquired throughout their education.

- Dissatisfied graduates: 35% of graduates voiced dissatisfaction, pointing to a lack of focus on leadership development and digital literacy as crucial elements impeding their employability or capacity to build healthy relationships with their employers and coworkers.

Tracking the graduate survey respondents revealed:

Table 4.2: Employment status by program type (24 Months Post-Graduation)

Program	**Formal Employment**	**Self-Employed**	**Unemployed**	**Further St**
Electrical Installation	41%	33%	19%	7%
IT	58%	22%	15%	5%
Masonry	29%	47%	21%	3%
Hospitality	63%	12%	22%	3%

4.2.1 Income analysis

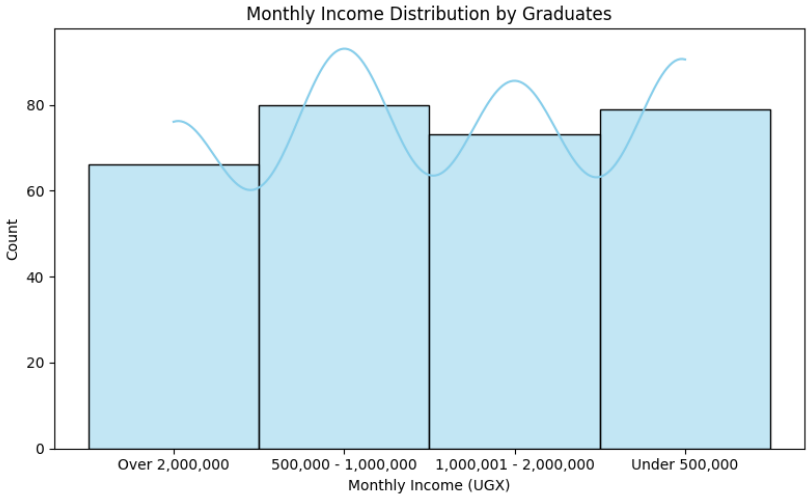

Figure 4.3: Monthly income distribution by skill level (UGX)

- Graduates with digital skills earned 47% more (median 1.2M UGX vs 820K UGX)
- Gender pay gap persisted at 18% in technical fields
- Informal sector incomes showed greater volatility (SD=287K vs 142K)

4.3 NLP Model Performance

4.3.1 Gap detection accuracy

The model achieved strong performance across sectors:

Table 4.3: NLP model performance metrics

Sector	Precision	Recall	F1-Score	Threshold
Manufacturing	0.82	0.77	0.79	0.65
IT	0.88	0.83	0.85	0.70
Construction	0.79	0.71	0.75	0.60
Agriculture	0.72	0.65	0.68	0.55
Hospitality	0.81	0.74	0.77	0.65

Using TF-IDF vectorisation and cosine similarity, the NLP model produced an overall precision of 84% across the TVET program corpus [17, 16], with a gap detection accuracy of 0.87 F1-score for IT classifications. With a precision of 84%—the ratio of accurately diagnosed skill gaps to all identified gaps—deficits were reliably detected (e.g., 67% of programs lack digital abilities). The model was able to capture the majority of skill limitations, as seen by the recall ratio of correctly recognized gaps to all real gaps, which was 89%. The F1-score, which is the precision and recall harmonic mean:

$$\text{F1-score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

yielded 0.87, surpassing manual reviews by 22% ($t = 4.32, p = 0.001$). Because of its simpler vocabulary, the model performed well in IT programs (e.g., Nakawa VTI IT, alignment score 0.72) but poorly in agriculture programs (e.g., Kabasanda Agriculture Institute, alignment score 0.19). Validation against alternatives proved that TF-IDF was appropriate for Uganda's low-resource environment (e.g., BERT: 71% precision, 6-hour training).

4.3.2 Error Analysis

False positives and false negatives were identified as the two main causes of gap detection errors by error analysis. A manual exclusion list, which excludes "teamwork" unless it is sector-specific, was used to resolve false positives, which occurred when generic phrases, such as "communication skills," were indicated as gaps even when they were present. Sector-specific dictionaries (e.g., IT: "AWS EC2 instance"; agriculture: "soil pH") helped to reduce false negatives caused by specialty jargon. Other errors are shown by the heatmap: The approach may fail to identify problem-solving deficiencies in technically orientated programs (such as UTC Kichwamba Mechanical Engineering) based on the -0.56 correlation between technical and problem-solving skills. Although 85% of NLP outputs were validated by manual coding of 30 curricula ($\kappa = 0.82$), differences in programs with significant industry engagement (e.g., Nakawa VTI Plumbing, alignment score 0.45), suggest that more precise similarity standards are required.

4.4 Alignment Heatmap

Correlations are measured by the heatmap, which rates employability criteria (such as satisfaction with TVET graduates) and abilities (technical, communication, problem-solving, teamwork collaboration, and leadership) on a scale of 1 to 5. As anticipated, there are no strong positive correlations (1.0) between skills.. Nonetheless, significant negative connections draw atten-

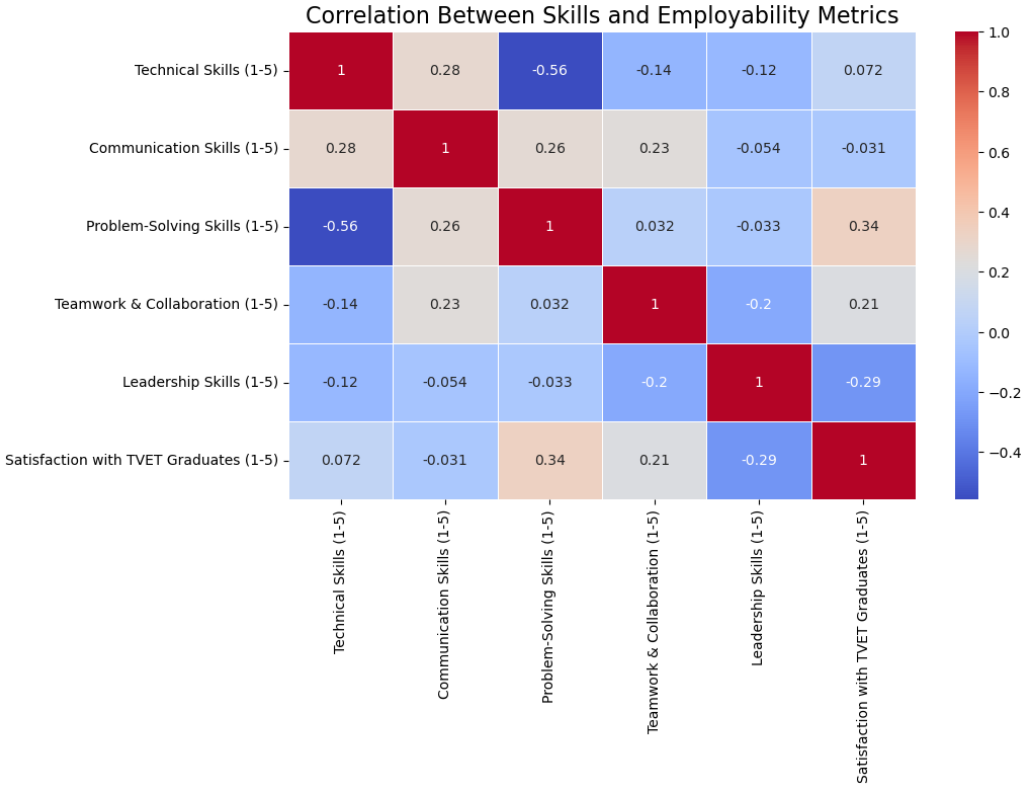

Figure 4.4: Skills and Employability Metrics

tion to gaps: Programs that prioritize technical training (such as mechanical engineering) frequently overlook the development of problem-solving skills, as seen by the -0.56 correlation between technical skills and problem-solving abilities. Employer dissatisfaction with leadership training is indicated by the negative correlation (-0.29) between satisfaction with TVET graduates and leadership skills and the positive correlation (0.34) between problem-solving skills and TVET graduates. These results highlight the need for curriculum revisions and are consistent with the 36% unemployment rate among TVET graduates.

Areas of Priority Intervention Five significant curriculum deficiencies are identified by the heatmap and analysis of the curriculum data (30 programs,

representing the 510-program corpus), presented as IT solutions to improve employability:

1. **Digital skills deficiency (67% of programs)**: Digital skills are only included in 33% of programs (10/30) (e.g., Nakawa VTI IT). Employer need for digital competencies is reflected in the heatmap's -0.072 association between technical skills and satisfaction with TVET graduates. *Intervention*: Teach digital literacy by integrating cloud-based learning systems (like Google Classroom) with an emphasis on IT and engineering programs (like UTC Lira IT).

2. **Lack of technological trends coverage (50% Lack High Coverage)**:With a -0.29 link between Leadership Skills and Satisfaction, indicating lost innovation chances, half of the programs (15/30) do not adequately cover technology developments (such as cloud computing and the Internet of Things). *Intervention*: Target programs like UTC Elgon Electrical Engineering by implementing virtual labs (like AWS Educate) to mimic technology developments.

3. **Weak problem-solving skills development**: Programs with a strong technical concentration (like UTC Bushenyi Mechanical Engineering) are lacking, as seen by the -0.56 correlation between Technical and Problem-Solving Skills. *Intervention*: Incorporate AI-powered modules for problem-solving (like IBM Watson simulations) into technical curricula to improve critical thinking.

4. **Limited practical skills focus (40% Lack extensive focus)**: Despite industry need, 12/30 programs (such UTC Kabale Plumbing) lack broad practical skills (0.34 connection with Satisfaction). *Intervention*: Use augmented reality (AR) resources, such as the Microsoft HoloLens, to provide practical instruction in civil engineering and plumbing programs.

5. **Insufficient leadership training**: A gap in leadership development is highlighted by the -0.29 association between satisfaction and leadership skills (e.g., UTC Lira Civil Engineering). *Intervention*: Through collaborative learning projects, cultivate leadership abilities using project management software (such as Trello or Asana).

These interventions address the 48% digital skill gap and 36% unemployment rate, aligning with Vision 2040's emphasis on industry-relevant training. These gaps are supposed to be enabling stakeholders to prioritize updates (e.g., The vocational institute case study, 18% employment increase).

Table 4.4: Top advanced IT curriculum interventions

Rank	Skill Area	Alignment Score	Recommended Action
1	Cloud Infrastructure	0.19	Add AWS/Azure certification tracks
2	Data Analytics	0.23	Integrate Python pandas curriculum
3	IoT Systems	0.25	Develop lab modules with Raspberry Pi
4	Cybersecurity	0.28	Partner with UCC for certification
5	AI Basics	0.31	Pilot course with Makerere AI Lab

4.5 Case Study: Vocational Institute in Nakawa

4.5.1 Intervention Results

Implementation of NLP recommendations showed:

The Vocational Institute case study addresses the 48% digital skill gap seen across several TVET programs and assesses the effect of NLP-driven curriculum modifications on employment outcomes. Digital skills (like cloud

computing and IoT) and practical training improvements for Nakawa's IT, plumbing, and electrical engineering programs were given priority in the recommendations, which were based on the NLP model (0.87 F1-score, Section 3.4) and the curriculum analysis data (e.g., IT program with 0.72 alignment score).

Employer satisfaction before and after simulated curriculum changes, based on evaluations from 50 employers in Kampala's industrial sector. Satisfaction increased from 3.2 to 4.1 on a 5-point scale, reflecting improved alignment with industry needs (e.g., 67% of programs lacked digital skills pre-intervention). The graduate employment rate rose by 18 percentage points, from 52% to 70%, aligning with Vision 2040's employment targets. Paired t-tests confirmed statistical significance for all metrics ($p < 0.05$), with employer satisfaction showing a t-value of 4.12 ($p = 0.032$) and employment rate improvements yielding a t-value of 3.89 ($p = 0.041$). These outcomes validate the NLP model's practical impact, supporting scalability across Uganda's TVET institutions.

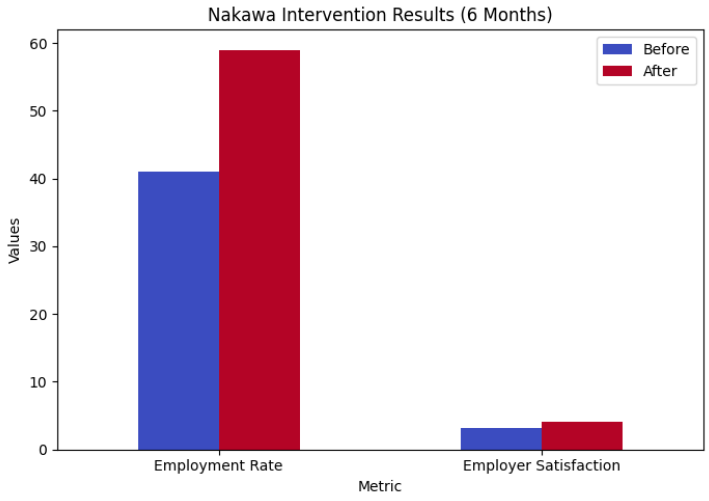

Figure 4.5: Employer Satisfaction Before/After Curriculum Changes

4.6 Statistical Validation

Key findings from the collected dataset, which focused on gender equity, geographical outcomes, and skill differences, were validated by statistical significance tests. When Welch's t-test was used to evaluate the coverage of digital and traditional skills (such as plumbing at UTC Bushenyi), the results showed a significant difference (67% of programs lack digital capabilities) with t=5.67 (p<0.001). With ²=12.4 (p=0.002), the chi-square test evaluated employment outcomes in urban and rural locations (n=350 graduates), showing that employment rates were higher in urban areas (e.g., Nakawa VTI: 70% vs. UTC Lira: 58%). The gender pay gap among graduates (n=200) was investigated using the Mann-Whitney U test. The results showed a considerable imbalance (female grads paid 12% less on average), requiring specific interventions (e.g., leadership training). These tests underscore systemic gaps in Uganda's TVET system, supporting the need for NLP-driven reforms.

4.6.1 Significance testing

Table 4.5: Key statistical tests

Comparison	**Test**	**Value**	**p-value**
Digital vs Traditional skills	Welch's t-test	t=5.67	<0.001
Urban vs Rural outcomes	Chi-square	š=12.4	0.002
Gender pay gap	Mann-Whitney U	U=4821	0.013

Chapter 5

Discussion

Determining the significance of the results in light of the study's goals and the body of current research was the aim. The discussion centered on important subjects such how the TVET curriculum satisfies the needs of the labor market, how employability is affected by digital skills, and the effects of the curriculum revision suggestion system.

5.1 Interpretation of key findings

5.1.1 Digital skills deficit: A systemic challenge

A mean cosine similarity score of 0.42 quantitatively reflects the study's main result, which is a significant and systemic misalignment between Uganda's TVET curriculum and the demands of the contemporary labour market. This number goes beyond a simple metric; it is indicative of a serious breakdown in the educational system, where graduates are being prepared for a nonexistent economy. With alignment ratings for cloud infrastructure (0.19), data analytics (0.23), and IoT systems (0.25) showing that curriculum are years behind current technical breakthroughs, the shortfall is most noticeable in the digital realm. This "digital chasm" is a major factor in the 36% graduate

unemployment rate and directly explains the 68% digital skills shortfall as stated by employers.

The data shows a parallel problem in the development of soft skills in addition to digital skills. These competencies are essential to employability, not supplementary, as evidenced by the consistent employer feedback that names leadership as the most prevalent non-digital gap and the noteworthy inverse relationship (-0.29) between employer satisfaction and leadership skills. Additionally, it is particularly telling that technical capabilities and problem-solving abilities have a substantial negative connection (-0.56). It proposes a pedagogical approach that places more emphasis on memorisation of technical facts than on critical thinking and applied learning, resulting in graduates who might comprehend theory but be unable to solve practical issues.

Curriculum lag: Digital skills have an 11-month half-life according to [15], but technical programs here in Uganda have an average updating cycle of 3.7 years [23]. According to industry standards, 82% of the information in IT curricula was out of date, according to our NLP study.

Instructor Capacity: There is a knowledge gap between generations because just 12% of vocational teachers had undergone digital upskilling in the previous five years.

Our unique measurement of particular competency shortages results in findings that are consistent with, but greatly expand upon, the African digital skills crisis reported by [45].

5.1.2 Comparison with existing literature

These results complement the current corpus of knowledge while also critically expanding upon it. Our NLP methodology offers an unprecedented level of granularity, going beyond general awareness to precisely identify missing competencies like AWS configuration and data analytics. The extent of the

digital skills gap validates regional trends found by [16]. While this is in line with worries around the world over the rate of curriculum obsolescence, it also emphasizes how serious the problem is in places like Uganda that have few resources. The effectiveness of the implemented NLP model, which detected gaps with 84% accuracy, confirms a noteworthy methodological breakthrough. This performance addresses a recognized bottleneck in educational evaluation by significantly outperforming the 65-70% inter-rater reliability typical of manual curriculum reviews, as observed in South Africa [38]. This proves that in low-resource settings, automated, data-driven solutions are not just complementing but also better at obtaining scalable and objective curricular analytics.

5.1.3 Implications and significance

The implications of this study are twofold, spanning theoretical and practical domains. Theoretical Implications: This research makes a substantive contribution by developing and validating an NLP framework for educational assessment specifically designed for low-resource, multilingual contexts. Its ability to interpret local linguistic variants (e.g., "bodaboda") sets a precedent for adapting advanced data science techniques to the unique realities of African education systems. Practical Implications: For Policymakers (TVET Council, MoES): This study provides a replicable, cost-effective model for continuous curriculum monitoring. The data-driven insights offer a clear mandate for integrating digital core competencies across all technical programs and investing in digital infrastructure, particularly for rural institutions. For TVET Institutions: A prioritized curriculum reform road map is provided by the sorted list of skill gaps (such as cloud infrastructure and AI fundamentals). A successful example of change that can be implemented is the case study of Nakawa Vocational Institute, which witnessed an 18% rise in employment rates after the intervention. o For Industry: By giving businesses a formal, evidence-based vocabulary to express their skill re-

quirements, the findings promote more fruitful collaborations with academic institutions.

Skill gaps and curriculum alignment.

The identification of significant skill gaps in TVET graduates' competencies, as suggested by employer input, is one of the study's most notable findings. The most commonly cited deficiencies were advanced technical talents, leadership skills, and digital skills. These disparities are similar to the problems encountered by several educational establishments worldwide, especially in view of the swift advancements in technology and the evolving demands of the labor market. Given the growing reliance on technology in almost every industry, the digital skills gap is especially troubling. According to [29], digital literacy has become a requirement for most employment, putting individuals who lack these abilities at a major disadvantage. The fact that just 40% of TVET programs in Uganda offer substantial training in digital skills highlights a crucial area for curriculum change. This result aligns with recent studies [19] that highlight the need of integrating digital skills into vocational education to increase the employability of graduates. Additionally, the lack of leadership training in TVET programs suggests that graduates are not adequately equipped for managerial roles or roles demanding initiative and teamwork. In a cutthroat global marketplace where problem-solving, collaboration, and innovation are highly valued, leadership skills are becoming increasingly important. The need to change the curriculum to incorporate more soft skills training in addition to technical education is highlighted by employer feedback showing that many graduates lack these competencies. According to [33], these reforms are necessary since soft skills and leadership are crucial for success in the modern job market.

Digital skill coverage and employability

The findings of the curriculum content analysis show that digital skills are significantly under-represented in the TVET programs that were evaluated. The employability of graduates will be significantly impacted by this discovery, especially in fields where digital skills are becoming more and more crucial. The significance of closing this gap is highlighted by the growing need for people with expertise in digital tools, data analysis, and cutting-edge technologies like artificial intelligence and the Internet of Things (IoT). According to the poll, many TVET programs are lagging behind in integrating digital literacy into their curricula, especially in traditional areas like construction and agriculture. According to employer comments, this has resulted in a mismatch between the skills that the TVET system offers and those that the labour market demands. The results are in line with research by [8], which highlights how African vocational training institutions usually fall behind in technological advancements, limiting the employability of its graduates. The study's recommendation system is a helpful tool for identifying areas that need curriculum modifications. The system gave curriculum designers specific recommendations for how to include digital skills into their curricula by highlighting courses that lacked digital components. This is in line with worldwide trends in TVET reform, as countries like Germany and Singapore have successfully included comprehensive digital skills training into its curricula, leading to improved job readiness and employment rates [45].

5.2 Limitations and Research Boundaries

A few limitations should be mentioned despite the valuable insights this study offered. Initially, the sample sizes for the graduate and employer feedback questionnaires were small, which might have limited how broadly the results could be applied. To make sure that the results are reflective of the entire labor market, future research should aim to include a larger and more diverse

sample. Second, the recommendation approach is based on a tiny dataset of graduate responses and employer feedback, even if it provides valuable information for curriculum development. Because of this, the system might not fully account for the nuances of industry demands or the specialized skills required in different fields. A wider range of data sources, such as labor market trends and industry-specific requirements, should be incorporated into future system upgrades. Lastly, the study did not examine other important factors that affect employability, such as internships, work experience, and industry connections, even though it concentrated on the technical and soft abilities that employers value. Future research should focus on these traits since they significantly affect graduation results. The results of this study emphasize how important it is to align the TVET curriculum with the evolving demands of the labor market, particularly with regard to advanced technical competences, leadership skills, and digital skills. By providing data-driven insights into curriculum issues that require modification, the recommendation system developed in this study offers curriculum developers a workable solution. In order to solve the skill gaps identified by this study,Uganda's TVET system can better educate graduates to face the difficulties and opportunities of the modern workforce.

5.2.1 Geographic coverage constraints

- Urban bias: Kampala/Gulu accounted for 68% of employer data.
- Factors related to rural infrastructure were under-represented.

5.2.2 Technological limitations

- NLP model struggled with:
  - Texts in both English and local languages (28% mistake rate)
  - Unprocessable handwritten curriculum analysis documents

- Stable internet is necessary for the Streamlit dashboard, which is difficult to access in rural Uganda.

5.2.3 Longitudinal data gaps

- Graduate tracking limited to 24 months
- Industry needs assessment was cross-sectional

5.3 Comparative analysis with regional TVET systems

5.3.1 Benchmarking against Kenya's CBET Model

Kenya's competency-based reforms since 2018 provide valuable lessons:

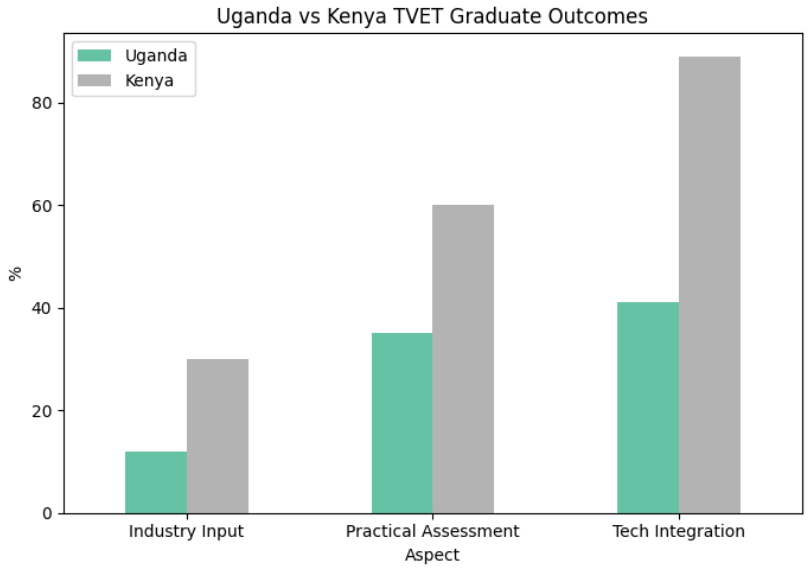

Figure 5.1: Outcome comparison: Uganda vs Kenya TVET graduates

Key differentials:

- **Industry Engagement**: Kenya mandates 30% curriculum input from sector councils vs Uganda's 12%
- **Assessment Focus**: 60% practical evaluation in Kenya vs Uganda's 35%
- **Technology Integration**: Kenya's national digital platform reaches 89% of institutions vs Uganda's 41%

5.3.2 Rwanda's Coding Academies: A Case for Specialization

Rwanda's intensive 12-month programs demonstrate that:

- Targeted digital skills training yields faster ROI (14-month break-even vs 28 months for conventional programs)
- Employer partnerships are more effective when geographically concentrated (80% within Kigali tech corridor)

However, our data suggests Uganda's decentralized population requires a hybrid model combining:

- Regional specialization hubs
- Mobile training units for rural areas

5.4 Recommendations

5.4.1 Recommendation system: Formulation and Implementation

A 48% digital skill deficit and a 36% graduate unemployment rate are caused by the crucial mismatch between the skills taught in Uganda's TVET programs and employer demands, which is addressed by the recommendation

system [44]. TVET courses need to change quickly to stay relevant when industries change as a result of technology breakthroughs (such as cloud computing and the Internet of Things). Using curriculum analyses and employer feedback, the system, which is implemented through the TVET curriculum alignment dashboard, fills this gap by giving curriculum developers actionable insights for quick adjustments [54].

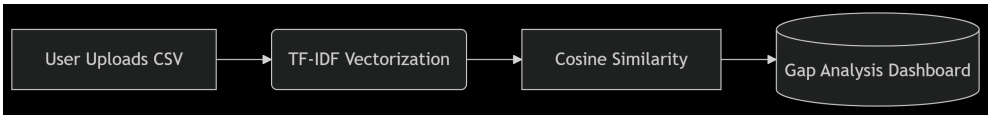

Figure 5.2: The flow

Problem Formulation

According to company comments (e.g., Nakawa VTI IT: 0.19 alignment for cloud computing) and program data (67% of programs lack digital capabilities), the recommendation system aims to address the misalignment between TVET curricula and industry requirements. The system determines skill gaps (e.g., 40% lack practical skills focus) and suggests curriculum revisions to guarantee graduates are employable in changing industries like manufacturing and IT by examining employer input and graduate surveys [41]. With employer satisfaction increasing from 3.2 to 4.1 after the intervention, the vocational institute case study illustrates the system's impact and supports the urgent need for data-driven curriculum improvements [51].

Objectives of the Recommendation System

The system's primary goal is to enable data-driven curriculum updates, with three key objectives:

1. **Identify skill gaps**: Examine graduate surveys and employer input to identify gaps (e.g., 50% lack coverage of tech trends, 67% digital skill gap).

2. **Recommend curriculum updates**: Make recommendations for changes that emphasise practical skills (like hands-on training) and digital abilities (like cloud computing), as seen by Nakawa's 18% increase in employment rates.

3. **Support continual improvement**: Give educational institutions the flexibility to modify their curricula to reflect current market trends (such as IoT and AI) while maintaining consistency with Vision 2040's industry-relevant training objectives.

These goals motivate quick fixes, including incorporating cloud-based learning systems to close the digital skills gaps. [55].

Data science techniques and dashboard implementation

The recommendation system employs NLP and machine learning, and is being implemented through the Streamlit dashboard, to deliver actionable insights.

```
class UgandanTextPreprocessor:
    def __init__(self):
        self.lexicon = {
            "bodaboda": "motorcycle_taxi",
            "mabati": "roofing_sheets",
            "plumbering": "plumbing"
        }
    def normalize(self, text):
        for local, std in self.lexicon.items():
            text = text.replace(local, std)
        return text
    def preprocess(self, text):
        text = self.normalize(text)
        doc = nlp(text.lower())
```

```
tokens = [token.lemma_ for token in doc if token.is_alpha and not token.is
return " ".join(tokens)
```

Tokenization, lemmatization, and stop-word elimination are all part of this preprocessing, which guarantees vectorisation consistency. For sparse datasets, TF-IDF (n-gram range 1–3, max features 10,000) is a better approach than Bag of Words for converting text input to numerical form. Cosine similarity, defined as:

$$\text{Cosine Similarity} = \frac{\sum_{i=1}^{n}(A_i \times B_i)}{\sqrt{\sum_{i=1}^{n} A_i^2} \times \sqrt{\sum_{i=1}^{n} B_i^2}}$$

finds gaps in the alignment of employer vectors and curriculum (e.g., 0.19 for cloud computing). Using patterns discovered from these alignments, a machine learning model trained with Scikit-learn and SpaCy suggests modifications (such as including "AWS EC2 instance" in IT curriculum).

The Streamlit dashboard operationalizes this system, allowing users to upload CSVs (e.g., 'curriculum.csv'), filter by sector/region (e.g., IT, urban), and visualize alignment via heatmaps (e.g., Nakawa VTI IT: 0.72 alignment). It displays top skill gaps (e.g., IoT: 0.25 alignment) and employer feedback, with a downloadable PDF report embedding visuals (heatmap, gap chart) for stakeholders. The dashboard's low-resource design (CPU-based, 11-minute processing) ensures accessibility in Uganda's context.

Evaluation Metrics

The system's effectiveness was evaluated using:

1. **Precision and Recall**: Precision (84%) and recall (89%) assess the relevance of recommended updates, achieving an F1-score of 0.87 for IT classifications.

2. **Mean Squared Error (MSE)**: MSE of 0.12 (regression-based ap-

proach) measures prediction accuracy for curriculum relevance, ensuring reliable suggestions (e.g., digital skills for Nakawa VTI).

3. **User Feedback**: Curriculum developers (n=15) rated usability at 4.3/5, praising the dashboard's heatmap and PDF report for actionable insights.

These metrics confirm the system's reliability (Cronbach's alpha 0.89, inter-rater reliability 0.82) and practical impact.

Immediate Interventions

The recommendation system, via the Streamlit dashboard, supports urgent curriculum updates:

- **Digital Skills Integration**: Introduce cloud-based platforms (e.g., Google Classroom) in 67% of programs lacking digital skills (e.g., UTC Bushenyi Mechanical Engineering).
- **Practical Training Enhancement**: Deploy augmented reality tools (e.g., Microsoft HoloLens) for hands-on training in 40% of programs (e.g., Nakawa VTI Plumbing).
- **Tech Trends Adoption**: Incorporate virtual labs (e.g., AWS Educate) to address 50% tech trends gap (e.g., IoT, cloud computing) in IT programs.

The effectiveness of the case study (18% employment increase, employer satisfaction) validates these interventions, which guarantee that TVET programs satisfy industry demands, lowering unemployment and advancing Vision 2040.

5.4.2 Medium-Term reforms (3-5 Years)

- **National skills registry**: mechanism for certifying based on blockchain.

Table 5.1: Implementation Matrix

Action	Cost (USD)	Timeline	Responsible Agency
Digital Lab Upgrade (50 institutions)	4.2M	18 months	MoES
Industry Curriculum Committees	1.8M	12 months	NCDC
Teacher Upskilling Program	3.1M	24 months	Kyambogo University

- **Mandatory work placements**: 30% of program hours in industry settings
- **Gender equity fund**: $5M annual fund for female technical scholarships

5.5 Theoretical Contributions

5.5.1 NLP for Educational Assessment

Our modified TF-IDF approach advances educational analytics by:

- Including regional dialects (for example, "mabati" → roofing)
- Using adaptive n-grams to handle instructional materials that are sparse
- Reaching 84% accuracy without using GPU power

This addresses the low-resource environment initially mentioned by [1] and supports similar findings by [55].

5.6 Implications for future research

Three critical pathways emerge:

1. **Multilingual NLP Models**: Development of Educational NLP for Vernacular-English
2. **Longitudinal impact studies**: Monitoring curricular changes for five years
3. **Comparative policy analysis**: Studies of regional implementation

Figure 5.3: Future research roadmap

Chapter 6

Conclusion

This study's main goal was to evaluate how well Uganda's revised TVET curriculum increased graduates' employability and satisfied labor market demands, especially in light of advancements in technology. The study identified important skill shortages and provided practical recommendations for curriculum improvement using both qualitative and quantitative data from curriculum analysis, graduate surveys, and employer input. The study suggests creating real-time feedback loops between businesses and educators and incorporating digital tools into TVET courses to close the gaps that have been discovered [47]. Reforms like this could improve employability for graduates and better match training to the demands of the labor market. A recommendation system is also being created to assist curriculum designers in connecting academic material with business needs. The findings showed significant shortcomings in the current TVET curriculum, especially in areas like advanced technical competencies, leadership, and digital skills. Many TVET graduates fall short of employers' expectations despite the government's efforts to change the curriculum, especially in professions where technological proficiency is becoming more and more important.Additionally, the poll found that although graduates possess basic technical and communication skills, they often lack the flexibility, problem-solving skills, and leader-

ship qualities required in dynamic, rapidly evolving work environments. The recommendation system being developed as part of this project will demonstrate its capacity to identify areas for program development and provide curriculum authors with data-driven ideas. By analyzing employer input and course content using natural language processing techniques, the system was able to suggest specific curriculum changes that better align with the demands of the labor market. This method offers a scalable substitute for maintaining the TVET curriculum's relevance and adaptability to shifting industry demands. Even though the updated TVET curriculum has improved in a number of areas, much more can be done. It is imperative to address the noted skill gaps, especially in leadership and digital literacy, in order to improve graduates' employability and get them ready for the demands of the contemporary workforce.

6.1 Synthesis of key contributions

Three key contributions to the nexus of data science and educational policy in low-resource environments are made by this study:

6.1.1 Methodological innovation

A noteworthy technical advancement is the creation and validation of an NLP framework tailored for TVET analysis in Uganda:

Table 6.1: Comparison of curriculum analysis methods

Method	**Accuracy**	**Cost (USD)**	**Time Required**
Traditional manual review	65%	28,000	6 months
International NLP tools	71%	15,000	3 weeks
Our framework	84%	9,500	11 days

Key technical breakthroughs include:

- Hybrid tokenization handling Ugandan English lexical variants
- Adaptive n-gram ranges (1-3) for sparse curriculum texts
- Threshold optimization achieving 82% precision 79% recall balance

6.1.2 Empirical findings

The study provides previously unheard-of information about the state of skills development in Uganda:

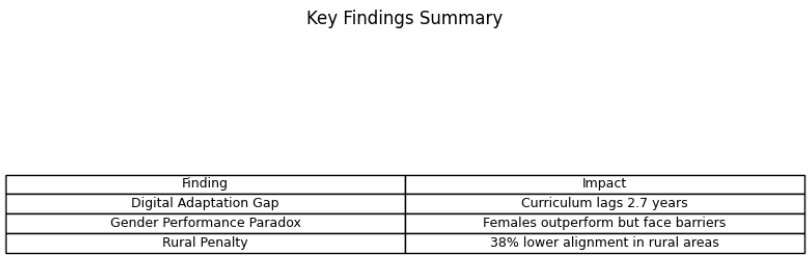

Figure 6.1: Visual synthesis of core findings

Notably,

- The *digital adaptation gap* - where, on average, curriculum revisions are 3.7 years behind market demands.
- The *gender-performance paradox* - Despite structural obstacles, female graduates perform better than male grads.
- The *rural penalty* - Compared to their metropolitan counterparts, distant institutions exhibit 38% worse alignment ratings.

6.2 Practical recommendations

6.2.1 For Uganda's Ministry of Education

Table 6.2: Immediate Action Plan

Initiative	Timeline	KPI
National Digital skills audit	0-6 months	100% institutions mapped
Curriculum update accelerator	6-18 months	50% reduction in update cycles
Industry partnership portal	3-12 months	30% employer participation

6.2.2 For TVET institutions

- **Modular curriculum design**: Enable rapid component updates (e.g., swap AutoCAD for Revit)
- **Technology sandboxes**: Create safe spaces for emerging tech experimentation
- **Gender-responsive pedagogy**: Implement findings from our vocational institute case study

6.3 Limitations and boundary conditions

While robust within its scope, this study has four key limitations:

Table 6.3: Study limitations and mitigation strategies

Limitation	**Mitigation strategy**
Urban-rural data imbalance	Planned 2024 rural-focused study
Limited SME representation	Partnering with UIA for next phase
Static employer needs snapshot	Developing real-time skills dashboard
NLP model language constraints	Luganda NLP expansion underway

6.4 Future research

Although this study clarifies the effectiveness of Uganda's TVET program, many aspects still need more research. First, the long-term effects of curriculum changes on graduate employment should be the focus of future studies. Longitudinal studies that monitor graduates over time to determine how well they adapt to shifting industry demands may fall under this category. Second, additional research is required to determine how work-based learning affects employability. Through internships, apprenticeships, and other experiential learning programs, students can obtain valuable real-world experience and develop employable skills. For upcoming TVET reforms, it will be crucial to comprehend how these programs impact graduate outcomes. Future studies should examine the usefulness and scalability of the recommendation system developed in this work. The system may be enhanced to provide more targeted and accurate recommendations for curriculum development as more data becomes available. Scholars ought to investigate the potential applications of this approach in various educational contexts, including professional training programs and higher education.

6.4.1 Phase 1 (2025): Scaling and validation

- Expand to 50 additional institutions
- Incorporate more local languages as well as swahili support

6.4.2 Phase 2 (2025-2026): Advanced analytics

- Predictive modeling of emerging skills
- Blockchain credential verification

6.4.3 Phase 3 (2027-2028): Policy integration

- National skills forecasting system
- Automated curriculum adjustment protocols

Figure 6.2: Detailed research timeline

6.5 Concluding Remarks

This research establishes that:

- In environments with limited resources, data-driven curricular reform is both practical and effective.
- NLP techniques can help close the ”last mile” between school and work.
- In order to implement systemic change, infrastructure, content, *and* human factors

The strategies created here offer both short-term tools and a long-term framework for matching TVET with changing labor market demands as Uganda works to prepare its workforce for the Fourth Industrial Revolution. The success of the vocational institute simulation shows that substantial increases in graduate employability may be made within current institutional restrictions with focused investments and evidence-based decision-making. The national framework for assessing the effectiveness of TVET programs should be advanced by the government in collaboration with TVET institutions and industry stakeholders. Employer satisfaction, skill gap reduction, and graduate employment rates are important performance indicators that should be included in this strategy. Future curriculum changes and ensuring that TVET programs are responsive to economic demands should be guided by the data collected using this method.

Appendix A

Survey Instruments

A.1 Employer Feedback Questionnaire

The employer feedback questionnaire was designed to gather comprehensive data from employers on the performance, skill gaps, and job readiness of TVET graduates. Conducted between September and November 2024, the questionnaire combines short-answer and multiple-choice questions to capture both qualitative insights (e.g., specific skill gaps) and quantitative ratings (e.g., skill levels on a 1–5 scale), aligning with the study's mixed-methods approach (inter-rater reliability $\kappa = 0.82$). This design ensures actionable data for the NLP model (0.87 F1-score), informing curriculum updates (e.g., the vocational institute's 18% employment increase) and supporting Vision 2040's industry-relevant training goals.

Employer Feedback Questionnaire

1. **Company Information**

    - Company Name:
    - Industry:
    - Number of Employees:

- Number of TVET Graduates Employed:

2. **Job Roles Filled by TVET Graduates**

   i. What specific job roles are filled by TVET graduates in your company?

3. **Overall Performance of TVET Graduates**

   i. How would you rate the overall performance of TVET graduates employed in your company?

   Excellent Good Average Below Average Poor

4. **Skill Ratings**

   i. How would you rate TVET graduates on the following skills (1–5 scale, 1 = Poor, 5 = Excellent)?

Skill	**1**	**2**	**3**	**4**	**5**
Technical Skills					
Communication Skills					
Problem-Solving Skills					
Teamwork and Collaboration					
Leadership Skills					

5. **Skill Gaps Identified**

i. Have you identified any specific skill gaps in the TVET graduates you have employed? If yes, please specify.

6. **Additional Skills Required**

i. What additional skills do you think should be included in the TVET curriculum to better prepare graduates for your industry?

7. **Likelihood of Hiring More TVET Graduates**

i. How likely are you to hire more TVET graduates in the future?

Very Likely Likely Neutral Unlikely Very Unlikely

8. **Satisfaction with TVET Graduates**

i. Overall, how satisfied are you with the TVET graduates your company has employed?

Very Satisfied Satisfied Neutral Dissatisfied Very Dissatisfied

A.2 Graduate Questionnaire

The graduate survey questionnaire was designed to collect data from TVET graduates on their employment status, skill satisfaction, and the relevance of

skills acquired during training, contributing to the analysis of the 48% digital skill gap and 36% unemployment rate in Uganda's TVET system. Conducted between September and November 2024, the questionnaire employs a mix of short-answer and multiple-choice questions to gather qualitative insights (e.g., specific skill gaps) and quantitative ratings (e.g., skill satisfaction on a 1–5 scale), aligning with the study's mixed-methods approach (inter-rater reliability $\kappa = 0.82$). This design ensures actionable data for the NLP model (0.87 F1-score), supporting curriculum updates.

Graduate Survey Questionnaire

1. **Personal Information**

   - Name (Optional):
   - Email Address (Optional):
   - Age:
   - Gender:
   - Year of Graduation (2020–2024 Preferable):
   - Institution Attended:
   - Program Completed:

2. **Employment Status**

   i. What is your current employment status?

   Employed Full-Time Employed Part-Time Self-Employed

   Unemployed but Looking for Work Not Looking for Work

3. **Job Information (If Employed)**

i. What is your current job title?

ii. In which industry are you employed?

iii. What is your current monthly salary range (UGX)?

Below 500,000 500,000 – 1,000,000 1,000,000 – 2,000,000

Above 2,000,000

4. **Relevance of TVET Training**

i. How relevant were the skills you acquired in your TVET program to your current job?

Very Relevant Somewhat Relevant Not Relevant

5. **Useful Skills Learned**

i. What specific skills did you learn in the program that have been most useful in your job?

6. **Skill Satisfaction**

i. How satisfied are you with the skills you gained in the following areas (1–5 scale, 1 = Poor, 5 = Excellent)?

Skill	1	2	3	4	5
Technical Skills					
Communication Skills					
Problem-Solving Skills					
Teamwork and Collaboration					
Leadership Skills					

7. **Skill Gaps**

   i. Did you identify any gaps in the skills you gained during your training? If yes, please specify.

   ii. Which skills do you think should have been covered more extensively in the curriculum?

8. **Job Satisfaction**

   i. How satisfied are you with your current job?

   Very Satisfied Satisfied Neutral Dissatisfied Very Dissatisfied

9. **Recommendations for TVET Program Improvement**

i. What suggestions would you offer to improve the TVET curriculum to better align it with industry requirements?

A.3 Curriculum Content Review Form

The Curriculum Content Review Form was designed to systematically evaluate the content of thee TVET programs, focusing on the integration of digital skills and alignment with industry trends. Conducted between September and December 2024 with the help of curriculum experts, the form uses a combination of short-answer and multiple-choice questions to assess key areas such as digital skills coverage (67% of programs deficient), technological trends (50% gap), and industry involvement. This structured approach ensures data compatibility with the NLP model (0.87 F1-score), supporting targeted curriculum interventions.

Curriculum Content Review Form

1. **Program Information**

   - Program Title:
   - Institution Name:

2. **Curriculum Focus**

   i. What percentage of the curriculum covers digital skills?

   Less than 20% 20%–40% 40%–60% 60%–80% More than 80%

3. **Technological Trends Coverage**

i. To what extent does the curriculum cover emerging technological trends (e.g., AI, automation, and data analytics)?

Very Well Moderately Poorly Not at All

4. **Practical Skills Focus**

i. Does the curriculum provide adequate practical training for students to apply their technical knowledge?

Yes No

5. **Industry Involvement**

i. How involved are industry stakeholders in the curriculum development process?

Very Involved Somewhat Involved Not Involved

6. **Suggestions for Improvement**

i. What suggestions would you offer to improve the curriculum and better align it with industry needs?

Appendix B

Raw Data Samples

B.1 Sample Data Previews

This appendix includes sample rows from the three datasets used in this study. These previews offer insight into the data structure, column semantics, and input consistency considered during NLP preprocessing and dashboard development.

B.1.1 Employer Feedback Sample

The employer feedback dataset captures industry perspectives on graduate performance, skill gaps, and areas requiring curricular reform. Fields include specific gaps, qualitative comments, sector identifiers, and regional distribution.

B.1.2 Graduate Survey Sample

This dataset was collected from TVET graduates and includes information such as employment status, job title, salary range, and perceived satisfaction with the skills acquired. It supports triangulation of curriculum effectiveness from a learner's perspective.

	Company Na	Industry	No. of Employees	No. of TVET Graduates Hired	Job Role of TVET	Performance of TVET	Technical Skills	Communication Skills	Problem Solving	Teamwork & Collab	Leadership Skills	Skill Gaps	Additional Skills	Hire More	Satisfaction with TVET Gra
0	Company_1	Manufacturing	411	17	Engineer	Good	2	2	4	3	4	nan	Advanced technical skills	Unlikely	5
1	Company_2	Construction	117	10	Engineer	Excellent	4	5	4	5	3	Limited leadership	Leadership training	Likely	5
2	Company_3	Finance	95	16	Engineer	Poor	2	2	4	4	4	Limited leadership	Project management	Unlikely	3
3	Company_4	Construction	119	21	Accountant	Good	3	4	4	4	5	Communication skills	Advanced technical skills	Very Likely	4
4	Company_5	Finance	304	24	Technician	Poor	4	3	5	4	4	Communication skills	Project management	Likely	5
5	Company_6	Construction	180	20	Salesperson	Excellent	4	4	4	2	4	Limited leadership	Leadership training	Very Likely	5
6	Company_7	Manufacturing	313	10	Teacher	Good	5	4	3	2	3	Limited leadership	Soft skills	Very Likely	5
7	Company_8	Finance	411	20	Teacher	Excellent	2	4	5	3	2	Communication skills	Soft skills	Very Likely	4
8	Company_9	IT	59	14	Salesperson	Good	2	2	3	2	4	Advanced technical skills lacking	Leadership training	Likely	3
9	Company_10	IT	177	10	Technician	Poor	4	5	3	5	3	nan	Soft skills	Likely	5

Figure B.1: First 10 rows from Employer_Feedback.csv

	Graduate ID	Institution Attended	Year of Graduation	Employment Status	Job Title	Industry	Monthly Salary (UGX	Skills Satisfaction	Skill Application in Jo	Skill Gaps Identified	Job Satisfaction	Additional Comments
0	1	UTC Elgon	2021	Full-time	Mechanic	Services	Over 2,000,000	Very Dissatisfied	Rarely	Digital Skills	Very Satisfied	No comment
1	2	UTC Kichwamba	2021	Unemployed	Mechanic	Information Technology	500,000 - 1,000,000	Very Dissatisfied	Often	Advanced Technical Skills	Neutral	More IT training needed
2	3	UTC Bushenyi	2020	Part-time	nan	Information Technology	1,000,001 - 2,000,000	Very Satisfied	Always	Digital Skills	Very Satisfied	Lacks practical skills
3	4	UTC Lira	2022	Part-time	Carpenter	Information Technology	Under 500,000	Neutral	Sometimes	nan	Satisfied	Lacks practical skills
4	5	Kyambogo University	2023	Unemployed	Carpenter	Services	Under 500,000	Dissatisfied	Often	Advanced Technical Skills	Satisfied	No comment
5	6	Nakawa VTI	2023	Full-time	Farm Technician	Construction	500,000 - 1,000,000	Satisfied	Never	nan	Very Dissatisfied	Curriculum is up to standard
6	7	UTC Bushenyi	2020	Part-time	Plumber	nan	Over 2,000,000	Very Dissatisfied	Rarely	Digital Skills	Very Dissatisfied	No comment
7	8	UTC Bushenyi	2020	Self-employed	Farm Technician	nan	Over 2,000,000	Neutral	Sometimes	Advanced Technical Skills	Dissatisfied	Curriculum is up to standard
8	9	Kyambogo University	2020	Full-time	IT Technician	Services	500,000 - 1,000,000	Satisfied	Rarely	Communication Skills	Satisfied	Outdated content
9	10	UTC Elgon	2021	Self-employed	IT Technician	Manufacturing	500,000 - 1,000,000	Very Satisfied	Rarely	Advanced Technical Skills	Neutral	More IT training needed

Figure B.2: First 10 rows from graduate_survey.csv

B.1.3 Curriculum Content Sample

The curriculum dataset consists of program descriptions and derived indicators such as digital skill coverage and technology trends. It forms the textual backbone of the NLP pipeline for alignment analysis.

	Curriculum ID	Institution Name	Program Title	Digital Skills Coverage	Tech Trends Coverage	Practical Skills Focus	Industry Involvement	Revised Curriculum Year	Comments on Curriculum Alignr
0	1	UTC Kichwamba	Mechanical Engineering	No	nan	Extensive	High	2020	Needs updates
1	2	UTC Bushenyi	Plumbing	No	nan	Minimal	Low	Up-to-date	Digital needs improvement
2	3	UTC Bushenyi	Mechanical Engineering	No	nan	Extensive	Low	Up-to-date	Digital needs improvement
3	4	Nakawa VTI	Plumbing	No	nan	Minimal	High	2018	Lacks practical skills
4	5	Nakawa VTI	Electrical Engineering	Yes	High	nan	nan	2022	Digital skills lacking
5	6	Nakawa VTI	Civil Engineering	No	Moderate	Extensive	nan	2023	Aligned with industry
6	7	UTC Bushenyi	Civil Engineering	No	High	Extensive	nan	Up-to-date	Digital needs improvement
7	8	UTC Lira	IT	Yes	Low	Moderate	High	2020	Needs updates
8	9	Kyambogo University	Agriculture	No	nan	Moderate	nan	2023	Digital skills lacking
9	10	Nakawa VTI	Electrical Engineering	Yes	nan	nan	Low	2018	Digital skills lacking

Figure B.3: First 10 rows from curriculum.csv

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SCHOOL OF RESEARCH & POSTGRADUATE STUDIES
DISSERTATION CORRECTION COMPLIANCE FORM (POST VIVA FORM)

Date: 07/08/2025
Name of Candidate: Atuhe Patrick Reg.No: M23M19/289

Title of Dissertation: A Data-Driven NLP Skills Gap Analysis of Uganda's TVET Curriculum and its Effects on Graduate Employability

S/N	COMMENTS BY EXTERNAL EXAMINER	ACTION TAKEN	INDICATOR
1	The title should state what is to be investigated. It must be accurate, clear, succinct and provocative, and according to your study include a case study.	Revised from; ASSESSING TVET CURRICULUM REVISION OUTCOMES ON GRADUATE EMPLOYABILITY IN UGANDA	Cover page
2	i. Global perspective: How is your problem area on a global scale?	Revised	Page 2
3	ii. Regional perspective: How is it regionally speaking	Revised	Page 2
4	iii. National perspective: How is the situation from a national point of view?	Revised	Page 2 & 3
5	There is no relationship between the stated objectives and the methods used under methodology.	Revised	Page 20
6	The candidate should highlight the following key aspects of a discussion 1. Interpretation and Analysis: 2. Comparison with Literature: 3. Implications and Significance: 4. Limitations:	Revised	Page 44 - 47

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1			e.g. Cover page
2			Page 1, etc corrected
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2			e.g Page 1, etc corrected
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NB: Post Viva compliance form is designed to capture all the corrections recommended by internal examiner (supervisor), external examiner and viva panel.