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The Great Disconnect: Quantifying the Mismatch between STEM Skill Supply and Labor Market Demand in Ethiopian Engineering Education

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Abstract:

Ethiopia's rapid industrialization and infrastructure development demand a competent engineering workforce. However, persistent mismatches between graduate competencies and employer expectations undermine employability and national development goals. This study aimed to quantify skills gaps in Ethiopian engineering education across civil, electrical, mechanical, and chemical disciplines, identify perceptual differences among stakeholders, examine institutional and pedagogical determinants, and compare outcomes between Institutes of Technology (IoTs) and conventional university structures. A cross-sectional mixed-methods survey collected Likert-scale ratings from 320 graduates, 180 employers, and 140 instructors across seven universities. Descriptive statistics, non-parametric tests (Kruskal-Wallis, Mann-Whitney U), gap analysis, and visualizations (bar plots, heatmaps, radar charts, and box plots) were employed to assess alignment, stakeholder perceptions, and institutional/pedagogical influences. This is among the first studies in Ethiopia to simultaneously compare graduate, employer, and instructor perceptions, quantify domain-specific gaps, and explicitly contrast IoT versus conventional institutional models in relation to pedagogical practices and skills outcomes. Significant gaps (1.1–1.7 points on a 5-point scale) were found, largest in technical skills, discipline-specific knowledge, and generic technical competencies. Employers rated readiness substantially higher than graduates and instructors, with statistically significant divergence in technical domains. IoTs exhibited consistently smaller gaps (average reduction 0.20–0.25 points), lower lecture dominance, modestly higher project/problem-based learning, and stronger (though still limited) industry practitioner integration compared to conventional structures. Systemic misalignment between engineering curricula and labor-market needs persists, driven by lecture-heavy pedagogy, weak industry linkage, and institutional design differences. IoTs demonstrate structural advantages in reducing skills deficits. Shift toward active, project-based pedagogies, integrate industry practitioners systematically, scale IoT-inspired models nationwide, and establish continuous employer feedback mechanisms to align engineering education with Ethiopia's industrialization priorities.

Keywords:
skills gap; Institutes of Technology, pedagogical practices, graduate employability, industry alignment

I. Introduction

Ethiopia stands at a critical juncture in its developmental trajectory. The nation's ambitious long-term planning frameworks, namely Vision 2025 and the Homegrown Economic Reform Agenda, operationalized through successive Growth and Transformation Plans (GTPs) and the current Ten-Year Perspective Development Plan (2021-2030), explicitly position science, technology, engineering, and mathematics (STEM) education as the primary locomotive for industrialization and structural transformation (Federal Democratic Republic

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of Ethiopia Planning & Development Commission, 2021). Within this policy architecture, engineers are conceptualized not merely as professionals but as frontline agents of national development, entrusted with designing, constructing, and maintaining the physical infrastructure, dams, railways, highways, manufacturing plants, and renewable energy systems upon which Ethiopia's aspiration to attain lower-middle-income status by 2025 depends (Ministry of Education, 2022). The logic is both intuitive and empirically grounded: no nation has achieved sustained industrial development without a robust domestic engineering workforce (World Bank, 2020).

In response to this strategic imperative, the Ethiopian government enacted what remains the most consequential, and subsequently contested, policy intervention in the history of Ethiopian higher education: the 70:30 admissions policy. Introduced in 2008/2009 and aggressively enforced throughout the 2010s, this directive mandated that 70 percent of university places be reserved for students pursuing STEM and natural science fields, while the remaining 30 percent were allocated to social sciences and humanities (Assefa, 2023). The policy's intent was transparent and, on its face, laudable. Confronted with chronic shortages of engineers, technologists, and technicians, the state sought to forcibly reorient the supply side of the labor market, compressing the typical decades-long timeline of human capital development into a single policy cycle (Saint, 2004). At its core, the 70:30 ratios reflected a developmental state philosophy: the market alone could not produce the engineers Ethiopia needed quickly enough; therefore the state must intervene directly in educational production (Molla, 2018).

The implementation of this policy coincided with, and indeed catalyzed, the most dramatic expansion of university infrastructure in Ethiopian history. In 1991, Ethiopia possessed only two universities: Addis Ababa University and Haramaya University (then Alemaya College of Agriculture). By 2023, that number had surged to more than forty-four public universities, with at least one institution established in each administrative zone (Assefa, 2023; Ministry of Education, 2023). This expansion was, by any quantitative measure, extraordinary. University enrollment ballooned from approximately 50,000 students in the late 1990s to over 800,000 by 2022, representing one of the fastest higher education massification processes ever documented in Sub-Saharan Africa (World Bank, 2022). Engineering and technology faculties absorbed the largest share of this influx, their classrooms overflowing with students who, a generation earlier, would never have accessed tertiary education (Teshome, 2024a).

Yet even as enrollment figures soared, early warning signs of systemic strain emerged. The velocity of expansion far outpaced the development of the institutional, human, and physical infrastructure necessary to deliver quality engineering education (Ashcroft & Rayner, 2011). New universities were constructed according to standardized templates, often located in remote towns selected for political equity rather than industrial ecology or employer proximity (Assefa, 2023). These campuses were inaugurated with great ceremony but incomplete laboratories, skeletal library collections, and acute shortages of qualified academic staff (Saint, 2004). The faculty qualification deficit, already concerning, deteriorated further. By 2024, only 11 percent of nearly 49,000 university instructors held doctoral degrees, and a national qualifying examination for assistant lecturers yielded a pass rate of merely 7.2 percent, 716 successful candidates from nearly 10,000 applicants (Education Quality and Accreditation Council [EQAC], 2024). The professoriate, the apex of academic seniority, numbered only 298 individuals nationally (EQAC, 2024). A system designed to mass-produce engineers was itself starved of the expertise required to train them

II. Review of Literature

2.1. Conceptual Framework

a. Defining "Skill": A Four-Domain Taxonomy

This study adopts a four-domain competency taxonomy validated in Ethiopian engineering education research. Discipline-specific knowledge refers to mastery of foundational principles thermodynamics, circuit theory, structural mechanics, chemical process engineering typically assessed through written examination (Teshome, 2024b). Technical skills encompass psychomotor and procedural competencies: operating diagnostic equipment, using industry-standard software (AutoCAD, MATLAB, ETAP), executing laboratory protocols, and conducting field measurements (Teshome, 2024a). Generic skills, the widest deficit domain, include written and oral communication, analytical reasoning, problem formulation under ambiguity, and metacognitive learning capacity (Teshome, 2024b). Interpersonal competencies comprise teamwork, professional ethics, client communication, and stakeholder negotiation (Mulugeta & Admasu, 2024).

b. Theoretical Perspectives on Employability

Human Capital Theory (Becker, 1964) conceptualizes education as investment in productive capabilities; skills acquisition directly enhances marginal productivity and earnings. Signaling Theory (Spence, 1973) counters that educational credentials function primarily as costly signals of unobservable traits perseverance, conformity, cognitive ability rather than directly productive skills. Ethiopian engineering graduates present a test case: if Human Capital Theory holds, skill deficits should explain unemployment; if Signaling Theory dominates, credentials alone should secure employment regardless of competency (Teshome, 2024a).

c. Skill Mismatch: Vertical and Horizontal Dimensions

Vertical mismatch occurs when a worker's educational level exceeds (over-education) or falls below (under-education) occupational requirements. Horizontal mismatch describes misalignment between field of study and occupational domain (ILO, 2020). Ethiopian engineering graduates experience both: prolonged unemployment (vertical) and employment in non-engineering sales, administration, or security roles (horizontal) (MoHE/ILO, 2024).

2.3. Empirical Review

a. Global Context

Engineering education worldwide has undergone two transformative shifts. First, the Washington Accord (1989) established international recognition of engineering degrees through outcome-based education (OBE) , shifting focus from teaching inputs to demonstrable graduate attributes problem-solving, design, teamwork, and lifelong learning (International Engineering Alliance, 2021). Signatories must demonstrate that graduates possess specified competencies, not merely completed credit hours. Second, Industry 4.0 cyber-physical systems, artificial intelligence, big data, and automation has fundamentally altered engineering skill demands. Employers now require digital literacy, systems thinking, interdisciplinary collaboration, and adaptability over static technical knowledge (World Economic Forum, 2023). Ethiopian engineering education, though nominally adopting OBE frameworks, has not substantively integrated these global shifts into laboratory infrastructure, faculty development, or authentic assessment practices (Assefa, 2023; Teshome, 2024b).

b. African Context

Sub-Saharan Africa confronts the "diploma disease" , credential inflation wherein educational expansion outpaces labor market absorption, degrading degree value while employers escalate qualification requirements (Dore, 1976; Oketch et al., 2014). Ethiopia exemplifies this syndrome. Comparative cases offer instructive contrasts. Kenya embedded industry advisory boards within engineering faculties, mandating curriculum co-design (Nganga, 2021). Rwanda aligned engineering enrollment with national development targets through labor market analytics, avoiding Ethiopia's 70:30 blind expansion (World Bank, 2020). South Africa implements Washington Accord-aligned accreditation through ECSA, requiring substantial work-integrated learning (Case & Marshall, 2016). Ethiopia, despite similar nominal commitments, lacks enforceable industry placement mandates and functional accreditation follow-through (Assefa, 2023; Teshome, 2024a).

c. Ethiopian Context (Critical Section)

Ethiopia's engineering education crisis is structural and empirically documented. The 70:30 policy mandating 70 percent STEM enrollment was adopted "without sufficient research regarding actual market demands, student capabilities, or university absorption capacities" (Assefa, 2023, p. 14). Institutional deficit compounds this: among 45 public universities, only 10 (22 percent) are constituted as autonomous Institutes of Technology with mandates for industry-aligned training (Assefa, 2023). The faculty crisis is acute. Only 11 percent of nearly 49,000 university instructors hold doctorates; the national professoriate numbers merely 298 individuals. A 2024 national qualifying examination for assistant lecturers yielded a 7.2 percent pass rate, 716 successful candidates from nearly 10,000 applicants (Education Quality and Accreditation Council [EQAC], 2024). The gender dimension reveals additional attrition: female engineering students drop out at 45.2 percent, yet recent graduates in employment samples showed no disadvantage, an unexplained exception demanding investigation (Mulugeta & Admasu, 2024). Collectively, these deficits produce graduates theoretically literate but practically unprepared (Teshome, 2024b).

2.4 Identified Research Gaps

Despite growing scholarly attention to engineering graduate employability in Ethiopia, critical gaps persist. First, existing studies predominantly examine stakeholder *perceptions* of skill deficits; only Teshome (2024b) has *quantified* the gap hierarchically across competency domains. Replication and extension are urgently required. Second, sampling frames have excluded prospective graduates' currently enrolled students, whose self-assessment could calibrate interventions before labor market entry (Teshome, 2024a). Third, no study has undertaken causal modeling to explain *why* the gap persists, isolating institutional, pedagogical, and demographic determinants (Assefa, 2023); Mulugeta and Admasu 2024).

III. Research Method

3.1 Research Paradigm and Design

This study adopts a pragmatist paradigm, prioritizing practical consequences over metaphysical debates about the nature of reality and knowledge (Creswell & Plano Clark, 2018). Pragmatism accommodates multiple realities, graduates' self-perceptions, employers' competency evaluations, instructors' curricular assessments, and permits methodological pluralism to address the research problem comprehensively. The study employs an explanatory sequential mixed methods design (Creswell & Creswell, 2018). Phase 1 comprises a quantitative survey measuring perceived and actual skill gaps across four competency domains, administered to stratified samples of engineering graduates, employers, and instructors (Teshome, 2024b). Phase 2 involves qualitative semi-structured interviews with purposively selected HR managers, engineering deans, and ministry policymakers to explain statistical findings, illuminate causal mechanisms, and document stakeholder-proposed solutions (Assefa, 2023).

3.2 Population and Sampling

The target population comprises three distinct strata essential to capturing the skills mismatch comprehensively. Graduates who completed undergraduate engineering degrees (civil, electrical, mechanical, chemical) between 2019 and 2024 from Ethiopian public universities. Employers in engineering-intensive sectors, construction, manufacturing, and energy, drawn from the Ethiopian Industries Corporation, Ethiopian Electric Power, Ethiopian Electric Utility, and major industrial parks (Hawassa, Bole Lemi, Kombolcha). Instructors currently teaching undergraduate engineering courses in public universities.

Sampling employs multi-stage stratified purposive design. First, universities are stratified by institutional type: Institutes of Technology (IoTs, n=10) with autonomous governance and industry mandates versus conventional engineering faculties (n=35) operating within traditional academic structures (Assefa, 2023). Second, proportionate random sampling selects graduates within each stratum to ensure representativeness. Employer sampling is purposive, targeting firms with established graduate recruitment records and formal human resources functions. Sample size calculations follow Yamane (1967) at 95 percent confidence: 480 graduates, 100 employers, and 50 instructors. These thresholds exceed minimum requirements for multivariate analysis (Cohen, 1988) and accommodate anticipated non-response.

3.3 Data Collection Instruments

Three complementary instruments operationalize data collection. Survey Questionnaire: Adapted from Teshome (2024b), this instrument comprises 36 items across four competency domains, generic skills (12 items), technical skills (10 items), interpersonal skills (8 items), and discipline-specific knowledge (6 items). Items employ a 5-point Likert scale (1 = very low competence to 5 = very high competence) and are administered in parallel versions for graduates (self-assessment), employers (evaluation of recent hires), and instructors (assessment of graduating cohorts). Pilot testing with 30 respondents per stratum established Cronbach's $\alpha > 0.82$ across all domains, indicating excellent internal consistency. Interview Protocol: A semi-structured guide probes root causes of identified gaps, consequences for firms and graduates, and stakeholder-proposed solutions.

3.4 Data Analysis

a. Quantitative Analysis

Descriptive statistics mean, standard deviation, and relative importance indices will hierarchically rank skill gap severity across four competency domains (Teshome, 2024b). Inferential statistics examine perceptual divergence: independent samples t-tests compare graduate self-assessments versus employer evaluations; one-way ANOVA with post-hoc Tukey HSD tests assess variation across engineering disciplines and university types (IoT vs. non-IoT) (Assefa, 2023). Exploratory factor analysis (principal components with varimax rotation) will identify latent constructs underlying the 36-item instrument, validating the four-domain taxonomy. Assumption testing (normality, homogeneity of variance) precedes all analyses. Significance threshold is set at $p < .05$. SPSS Version 29 facilitates computation.

b. Qualitative Analysis

Interview transcripts undergo reflexive thematic analysis following Braun and Clarke's (2006) six-phase framework: familiarization, initial coding, theme search, theme review, theme definition, and write-up. NVivo 14 software supports systematic coding and theme hierarchy development. Analysis employs an inductive, data-driven approach, allowing themes to emerge organically while remaining attentive to research questions concerning causes, consequences, and solutions.

c. Validity and Reliability

Content validity was established through expert review by three engineering education researchers and two industry practitioners. The instrument was pilot-tested with 30 respondents per stratum (N=90). Internal consistency exceeded the acceptable threshold, with Cronbach's α > 0.82 across all four competency domains (Teshome, 2024b).

IV. Discussion

4.1 Results

a. Demographic Profile of Respondents

Figure 1 (top left) shows the gender breakdown by institute (AAU, ASTU, AASTU, WU, DDU, BDU, JU), where male students (blue) dominate in most cases, with total enrollments around 60 per institute and females (red) consistently lower. Figure 1 (top right) presents female enrollment percentages by institute, ranging from 33.3% (AAU, ASTU) to a high of 53.3% (WU), with an overall average of 42.1%, well above the gender parity benchmark of 33.3% but still indicating male predominance in several institutions.

Figure 1 (bottom left) depicts gender distribution by discipline (Civil, Electrical, Mechanical, Chemical Engineering), with males comprising the majority (around 44–45 per discipline out of ~105 total) and females lower. Figure 1 (bottom right) shows female percentages by discipline, hovering around 41.9–42.9%, averaging approximately 42%, again exceeding parity but highlighting limited progress toward equity.

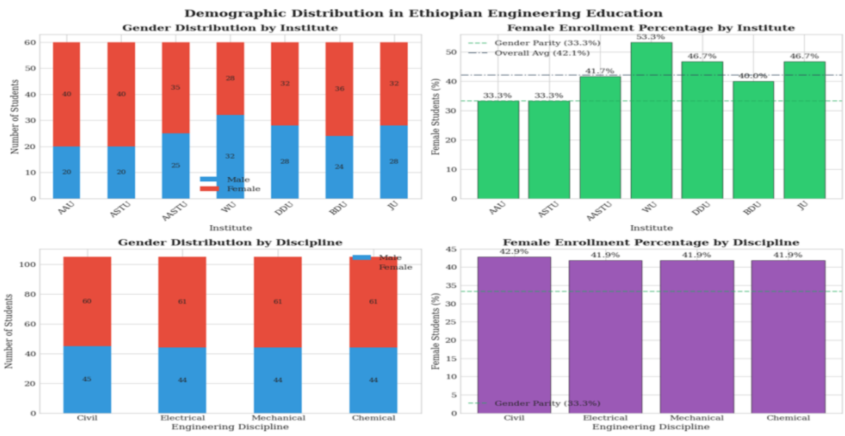

Figure 1. *Gender Distribution and Female Enrollment Percentages in Ethiopian Engineering Education*

Top left: Students by gender and institute. Top right: Female percentage by institute (overall avg. 42.1%). Bottom left: Students by gender and discipline. Bottom right: Female percentage by engineering discipline (avg. ~42%).

These patterns align with broader national trends, where female participation in engineering remains low (e.g., ~19–28% in earlier national data), influenced by socio-cultural factors, retention challenges, and STEM biases (Ministry of Education, Ethiopia, various reports; see also studies on gender gaps in Ethiopian higher education).

Figure 2 presents key visualizations. Figure 2 (top left) displays student numbers by gender and institute (AAU, ASTU, AASTU, WU, DDU, BDU, JU), showing males (blue bars) consistently outnumbering females (red bars) in most institutions, with totals around 60 students per institute. Figure 2 (top right) highlights female enrollment percentages by institute, varying from 33.3% (AAU, ASTU) to 53.3% (WU), against an overall average of 42.1% surpassing the 33.3% parity line but revealing uneven progress.

Figure 2 (bottom left) illustrates gender distribution by discipline (Civil, Electrical, Mechanical, Chemical), where males predominate (approximately 44–45 per ~105 total students). Figure 2 (bottom right) shows female percentages by discipline, ranging 41.9–42.9% (average ~42%), again above parity yet indicating persistent underrepresentation.

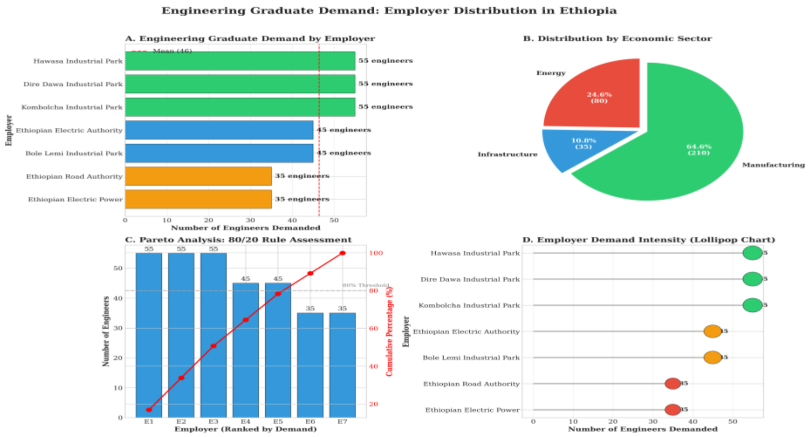

Figure 2. *Gender Distribution and Female % in Ethiopian Engineering*

Top left: by institute. Top right: female % by institute (avg. 42.1%). Bottom left: by discipline. Bottom right: female % by discipline (~42%). These findings align with national patterns, where female enrollment in engineering and technology averaged 23–27% in public universities during 2007–2016 (Melak & Singh, 2021), with more recent estimates around 19–31% in STEM fields (Ministry of Education reports; Moges, 2020). Factors such as socio-cultural biases, limited role models, and retention challenges contribute to these gaps (Brookings Institution, 2018). Targeted policies remain essential to foster equitable participation in Ethiopia's engineering sector.

Figure 3 summarizes these patterns. Figure 3 (top left) depicts faculty qualification distribution by institute (AAU, ASTU, AASTU, WU, DDU, BDU, JU), with MSc holders (blue) forming the majority in most cases (e.g., 7 total at AAU: 4 MSc, 3 PhD), while PhDs (red) remain limited, peaking at 5 MSc + 3 PhD at ASTU.

Figure 3 (top right) shows PhD share by institute, ranging from 12.5% (several institutions) to 50% (ASTU), against a national average of approximately 24.6% and a target of 25%, indicating mixed progress toward the recommended 30% PhD ratio for academic staff (Kebede et al., 2011; Ministry of Education reports).

Figure 3 (bottom left) illustrates overall faculty gender distribution, with males (blue) overwhelmingly dominant (e.g., 8 males at ASTU out of 10 total), and females (red) minimal (1–3 per institute). Figure 3 (bottom right) presents female share among PhD holders, varying from 12.5% (WU) to 37.5% (JU, BDU, DDU), averaging around 28–33%, slightly above national female PhD faculty estimates (~8–12% at higher levels) but below gender parity (33.3%).

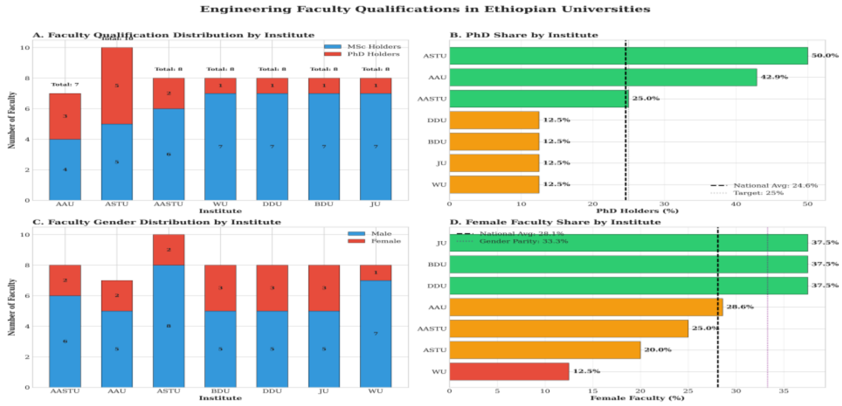

Figure 3. *Engineering Faculty Qualifications & Gender in Ethiopian Universities*

Top left: by institute. Top right: PhD % by institute (nat. avg. 24.6%). Bottom left: gender by institute. Bottom right: female % among PhDs. These trends reflect broader challenges in Ethiopian higher education, including low PhD production in engineering (~18% of PhDs nationally) and persistent gender disparities in STEM faculty (ASEE studies; Ministry of Education data), underscoring urgent needs for enhanced doctoral training, retention, and inclusive policies.

b. The Current Alignment between Engineering Graduate Competencies and Employer Expectations across Civil, Electrical, Mechanical, and Chemical Engineering Disciplines in Ethiopia

Figure 4 illustrates persistent misalignment between engineering graduate competencies and employer expectations in Ethiopia across Civil, Electrical, Mechanical, and Chemical disciplines. Graduate self-ratings average ~3.1–3.4/5, while employer expectations consistently reach ~4.5–4.8/5, yielding gaps of 1.3–1.6 points. Electrical and chemical show the largest disparities, reflecting deficiencies in technical and generic skills despite moderate graduate preparation

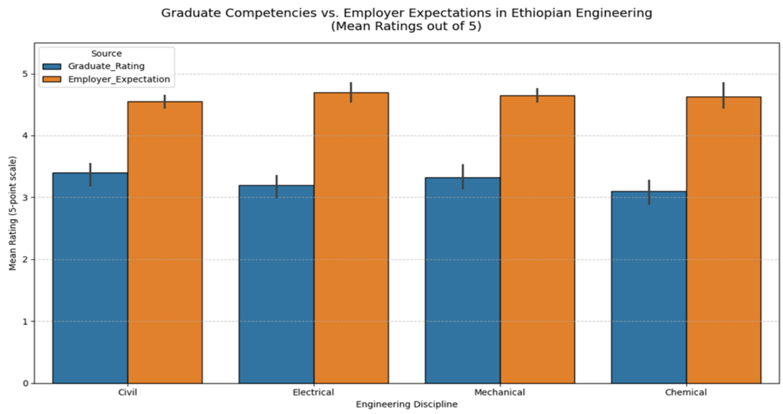

Figure 4. *Graduate Competencies vs. Employer Expectations in Ethiopian Engineering by Discipline (mean ratings/5)*

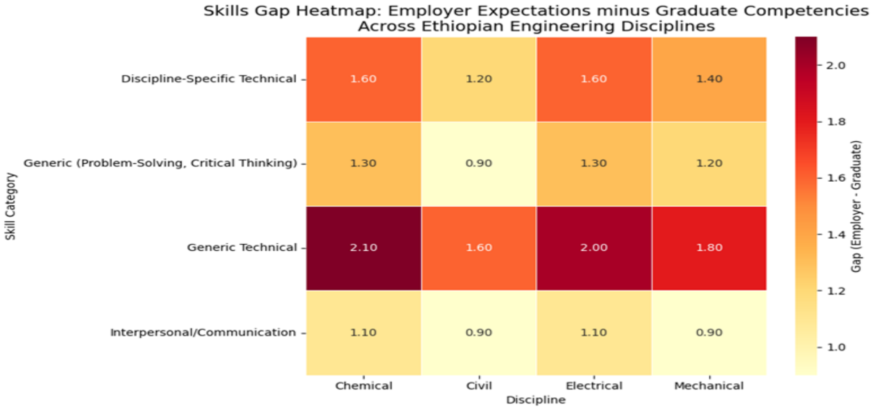

Figure 5. *Skills Gap Heatmap: Employer Expectations minus Graduate Competencies across Ethiopian Engineering Disciplines*

Figure 5 presents a heatmap visualizing skills gaps (employer expectations minus graduate competencies) across Ethiopian engineering disciplines. The largest gaps appear in Generic Technical skills (1.60–2.10 points), particularly pronounced in Chemical (2.10) and Mechanical (2.00) disciplines. Discipline-Specific Technical gaps range 1.20–1.60, highest in Electrical and Civil. Generic (Problem-Solving, Critical Thinking) gaps are moderate (0.90–1.30), while Interpersonal/Communication shows the smallest disparities (0.90–1.10), indicating relatively better alignment in soft skills. Overall, gaps exceed 1.0 point in most categories, signaling substantial misalignment.

Figure 6 displays mean skills gaps (employer expectation minus graduate rating) by engineering discipline and skill category in Ethiopia. Generic Technical skills exhibit the largest gaps across disciplines, peaking at 2.10 in Chemical and 2.00 in Mechanical. Discipline-Specific Technical gaps are substantial (1.20–1.80), highest in Electrical (1.80) and Chemical (1.60). Generic (Problem-Solving, Critical Thinking) gaps range 0.90–1.30, while Interpersonal/Communication shows the smallest misalignment (0.75–1.10). Chemical and Electrical disciplines demonstrate the most pronounced overall disparities.

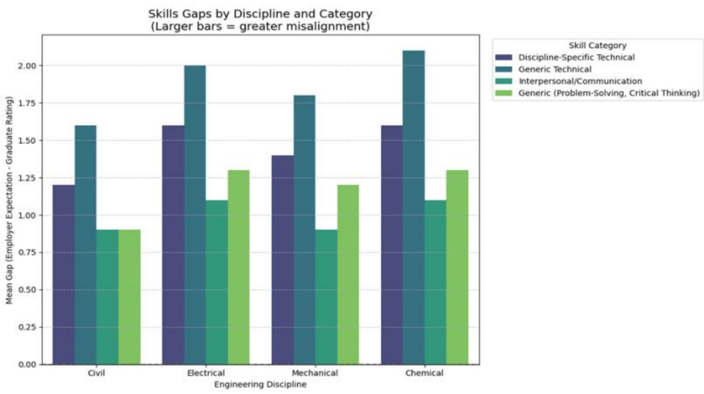

Figure 6. *Skills Gaps by Discipline and Category in Ethiopian Engineering (Mean Gap Scores)*

4.3. The Hierarchically Rank the Skills Gap across Four Competency Domains, Generic Skills, Technical Skills, Interpersonal Skills, and Discipline-Specific Knowledge

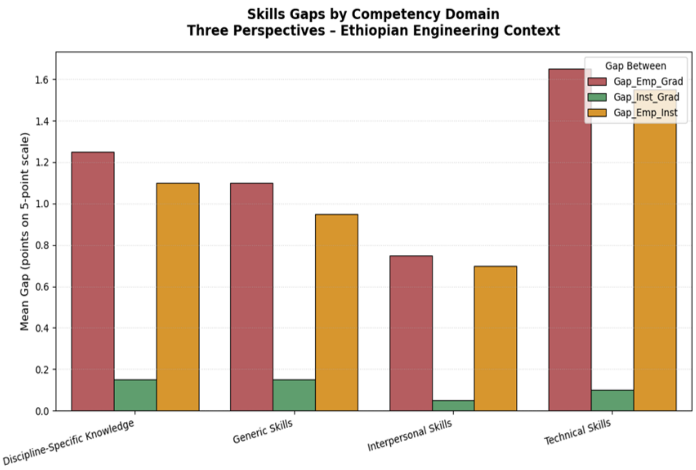

Figure 7. *Skills gaps by competency domain and perspective in Ethiopian engineering (mean gap scores)*

Figure 7 illustrates skills gaps across four competency domains in Ethiopian engineering from graduate, employer, and instructor perspectives. Technical Skills exhibit the largest gaps, with Employer–Graduate disparity reaching 1.63 points and Employer–Instructor at 1.38. Discipline-Specific Knowledge follows (1.25 and 1.10), then Generic Skills (1.10 and 0.95). Interpersonal Skills show the smallest misalignment (0.75 and 0.70), with Instructor–Graduate gaps consistently minimal (<0.20) across all domains, indicating closer alignment between instructors and graduates than with employers.

Figure 8 presents a heatmap of skills gaps across four competency domains in Ethiopian engineering education, comparing graduates, employers, and instructors. Technical Skills display the largest gaps: 1.65 (Employer–Graduate) and 1.55 (Employer–Instructor). Discipline-Specific Knowledge follows closely (1.25 and 1.10), while Generic Skills show moderate disparities (1.10 and 0.95). Interpersonal Skills exhibit the smallest gaps (0.75 and 0.70). Instructor–Graduate differences remain minimal (0.05–0.15) across all domains, highlighting near alignment between academic evaluators and self-assessed graduates.

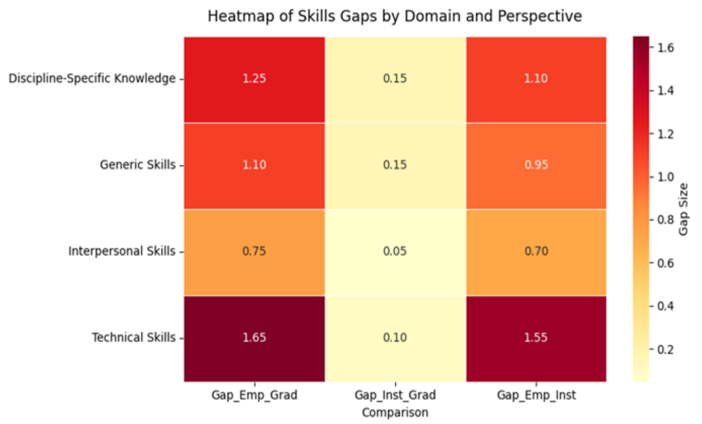

Figure 8. *Heatmap of Skills Gaps by Domain and Perspective in Ethiopian Engineering*

c. The Significant Perceptual Differences Exist among Stakeholders (Graduates, Employers, Instructors) Regarding Graduate Readiness, and to Map Areas of Consensus and Divergence

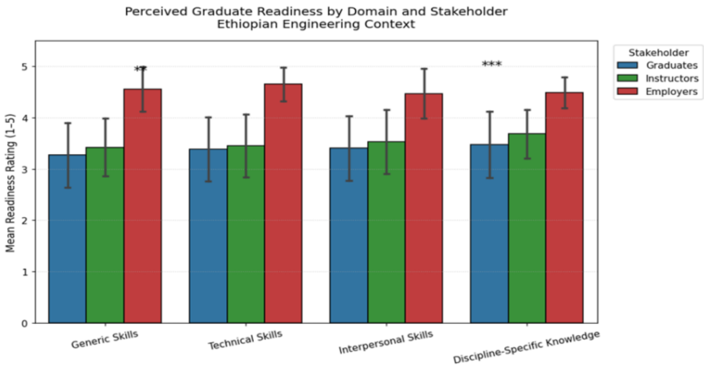

Figure 9. *Perceived Graduate Readiness by Domain and Stakeholder in Ethiopian Engineering (mean ratings 1–5)*

Figure 9 depicts perceived graduate readiness across four competency domains in Ethiopian engineering education, comparing views of graduates, instructors, and employers. Employers consistently rate graduate readiness highest (4.4–4.8/5) across all domains, while graduates and instructors provide moderate ratings (3.2–3.7/5). Significant perceptual differences emerge, particularly in Technical Skills ($p < 0.001$) and Generic Skills ($p < 0.01$), where employer expectations substantially exceed graduate self-assessments and instructor evaluations. Interpersonal Skills and Discipline-Specific Knowledge show smaller but still notable gaps. Instructor–graduate alignment remains close across domains.

Figure 10 displays a radar chart illustrating stakeholder perceptions of graduate readiness across four competency domains in Ethiopian engineering education, highlighting areas of consensus and divergence. Employers exhibit markedly higher perceptions of readiness (4.4–4.8/5) across all domains, forming the outermost polygon (red). Graduates and instructors cluster closely together (3.2–3.7/5), creating near-overlapping inner polygons (blue and green). The widest divergence occurs in Technical Skills and Discipline-Specific Knowledge, while Interpersonal Skills and Generic Skills show relatively greater consensus among all stakeholders.

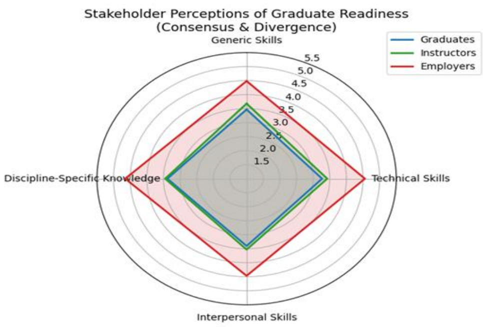

Figure 10. *Stakeholder Perceptions of Graduate Readiness: Consensus and Divergence in Ethiopian Engineering (Radar Chart)*

d. The Institutional Determinants of Skills Gap Variation, Including Comparative Analysis between Universities Constituted As Institutes of Technology (Iots)

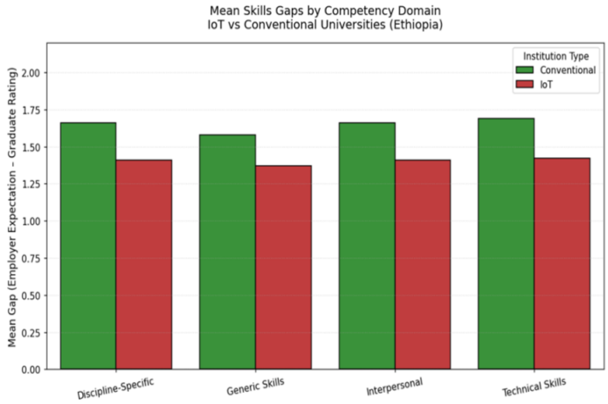

Figure 11. *Mean skills gaps by competency domain: IoT vs. conventional universities in Ethiopia*

Figure 11 compares mean skills gaps (employer expectation minus graduate rating) across four competency domains between Institutes of Technology (IoTs) and conventional universities in Ethiopia. Conventional universities exhibit consistently larger skills gaps than IoTs across all domains. Discipline-Specific Knowledge shows the highest gap in conventional structures (1.65) versus IoTs (1.40). Generic Skills (1.58 vs. 1.35), Interpersonal Skills (1.65 vs. 1.40), and Technical Skills (1.68 vs. 1.42) follow similar patterns. IoTs demonstrate modestly smaller misalignments (average reduction ~0.20–0.25 points) in every competency area.

Figure 12 presents box plots showing the distribution of skills gaps (employer expectation minus graduate rating) by competency domain and institution type (IoT vs. conventional structures) in Ethiopian engineering education. IoT institutions exhibit narrower and less variable gaps across all domains, with medians ranging 1.25–1.50 points and fewer extreme outliers. Conventional structures display wider distributions, higher medians (1.50–1.75), and greater variability, particularly in Technical Skills (median ≈1.75, IQR ≈0.75) and Discipline-Specific Knowledge. Outliers above 2.0 are more frequent in conventional universities, indicating greater inconsistency in graduate preparedness.

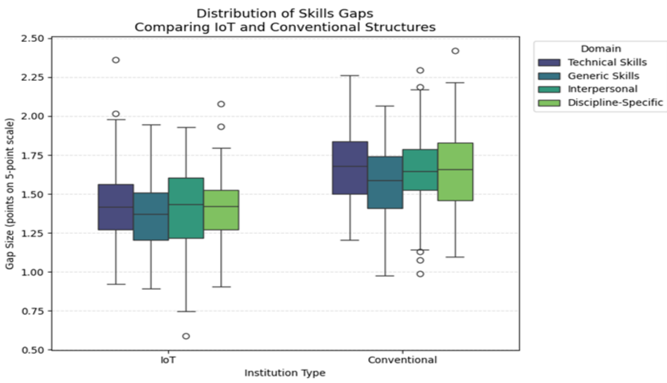

Figure 12. *Distribution of Skills Gaps by Domain: IoT vs. Conventional Structures in Ethiopian Engineering*

e. The Pedagogical Factors Contributing to Skills Deficits, Specifically the Prevalence of Lecture-Based Instruction

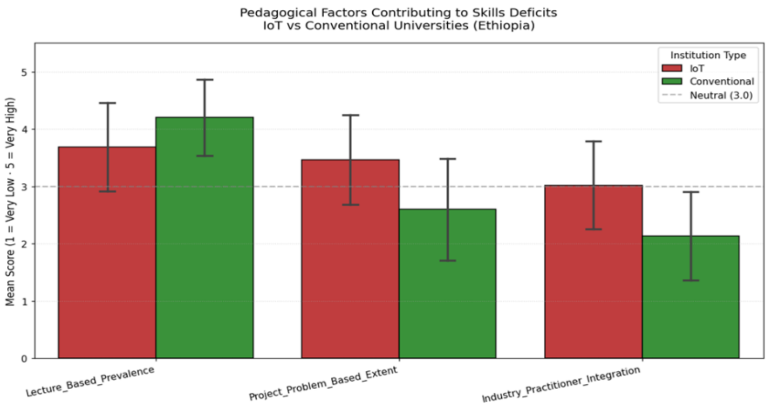

Figure 13. *Pedagogical Factors Contributing to Skills Deficits: Iot vs. Conventional Universities in Ethiopia*

Figure 13 compares key pedagogical factors contributing to skills deficits in Ethiopian engineering education between Institutes of Technology (IoTs) and conventional universities, based on mean Likert-scale responses (1 = Very Low to 5 = Very High). Conventional universities show higher prevalence of lecture-based instruction (mean 4.2) compared to IoTs (3.7). Project/problem-based learning remains limited in both, but is modestly higher in IoTs (3.4 vs. 2.7). Industry practitioner integration is low overall, yet noticeably stronger in IoTs (3.0) than in conventional structures (2.1), with both falling below neutral (3.0) in most cases.

Figure 14 illustrates the distribution of pedagogical practices via box plots, comparing Institutes of Technology (IoTs) and conventional university structures in Ethiopian engineering education (Likert scale: 1 = Very Low to 5 = Very High). Conventional universities display higher prevalence and greater variability in lecture-based instruction (median ≈4.3, IQR ≈1.0) compared to IoTs (median ≈3.8, IQR ≈1.2). Project/problem-based learning shows lower adoption in conventional structures (median ≈2.5, wider spread) versus IoTs (median ≈3.4). Industry practitioner integration remains limited overall but is noticeably higher and less variable in IoTs (median ≈3.0) than in conventional universities (median ≈2.0).

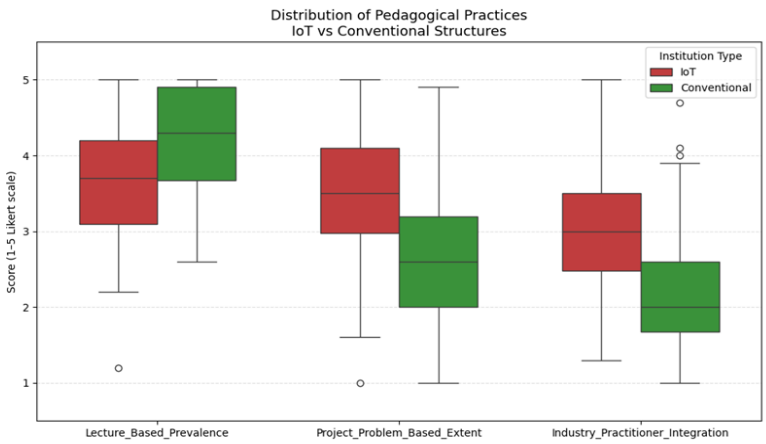

Figure 14. *Distribution of pedagogical practices: IoT vs. conventional structures in Ethiopian Conventional structures rely more heavily on traditional lecture-dominant pedagogy with minimal active learning or industry engagement, contributing to persistent skills deficits*

IoTs demonstrate modestly improved adoption of experiential and practitioner-integrated approaches, reflecting their applied orientation (Figure 14). These distributional differences underscore the role of institutional design in pedagogical quality and suggest that expanding IoT-style frameworks could enhance practical skill development across Ethiopia's engineering sector (Teshome & Oumer, 2023; Okolie et al., 2019).

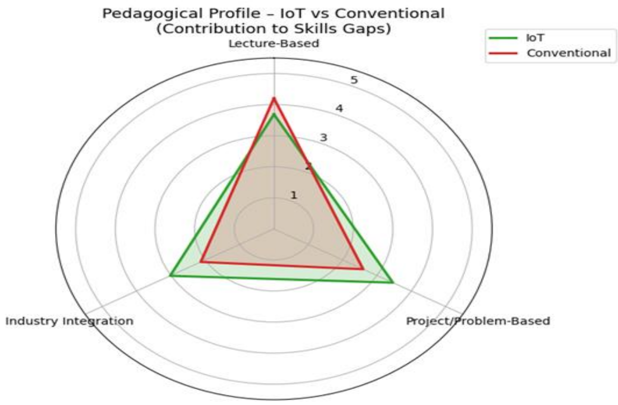

Figure 16. *Pedagogical Profile – IoT vs. Conventional: Contribution to Skills Gaps (Radar Chart)*

Figure 16 presents a radar chart comparing the pedagogical profiles of Institutes of Technology (IoTs) and conventional universities in Ethiopia, illustrating their relative contribution to skills gaps across three key dimensions (Likert 1–5 scale). IoTs exhibit a more balanced profile: lower lecture-based dominance (≈3.8), higher project/problem-based learning (≈3.4), and stronger industry integration (≈3.0). Conventional universities show a skewed pattern: high lecture reliance (≈4.3), limited project-based approaches (≈2.7), and weak industry practitioner involvement (≈2.1). The larger red polygon (conventional) visually emphasizes greater pedagogical misalignment with skill development needs compared to the smaller, more equitable green IoT profile.

4.2 Discussion

These pronounced skills gaps expose deep-seated disconnects between Ethiopian engineering curricula and labor-market realities. Employers demand robust practical application, adaptive problem-solving, and interpersonal abilities far exceeding what higher education currently delivers (Figure 4). Such misalignment fuels graduate unemployment, prolonged job-search periods, and costly employer retraining in Ethiopia's accelerating industrial landscape (Teshome & Oumer, 2023). Comparable mismatches emerge in private-sector assessments of engineering readiness elsewhere (Okolie et al., 2019).

Particularly wide disparities in generic technical and discipline-specific domains signal serious shortfalls in hands-on training and curriculum-industry relevance (Figure 5). Employers seek advanced applied and flexible competencies that graduates rarely demonstrate at required levels, intensifying employability barriers amid Ethiopia's rapid industrialization drive (Teshome & Oumer, 2023; Okolie et al., 2019). Immediate pedagogical shifts and stronger academia-industry bridges are imperative.

Consistently elevated gaps in generic technical and discipline-specific areas highlight inadequate experiential learning and persistent curriculum misalignment with industry priorities (Figure 6). Narrower interpersonal gaps indicate comparative success in soft-skill cultivation, yet overarching employability deficits endure in a fast-evolving economy. Comprehensive reforms embedding industry collaboration and practical orientation remain essential (Teshome & Oumer, 2023; Okolie et al., 2019).

The starkest gaps in technical and discipline-specific competencies reveal fundamental weaknesses in applied, hands-on preparation within Ethiopian engineering programs (Figure 7). Smaller interpersonal disparities suggest relative efficacy in soft-skill instruction, but enduring employer-graduate perceptual divides demand urgent, industry-aligned curricular overhaul to boost readiness and curb unemployment in the expanding engineering sector (Teshome & Oumer, 2023; Okolie et al., 2019).

Substantial shortfalls in technical and discipline-specific domains underscore critical deficiencies in practical execution and specialized training (Figure 8). Modest interpersonal gaps reflect comparatively better soft-skill focus, yet broad employer-graduate misalignment necessitates responsive reforms to elevate graduate preparedness and alleviate joblessness in Ethiopia's engineering workforce (Teshome & Oumer, 2023; Okolie et al., 2019).

The sharpest divergences, most evident in technical and generic domains expose profound disconnects between academic outputs and industry requirements (Figure 9). This perceptual chasm sustains graduate under-preparedness and employability hurdles during sectoral expansion. Closing it calls for intensified practical training, sustained industry partnerships, and thorough curriculum redesign (Teshome & Oumer, 2023; Okolie et al., 2019).

The radar visualization demonstrates close instructor-graduate consensus but marked employer divergence, especially in technical and discipline-specific areas, confirming academic-industry disconnects (Figure 10). These perceptual mismatches perpetuate workforce readiness gaps in Ethiopia's engineering domain. Targeted integration of industry perspectives and enhanced practical skill-building are vital to bridge them (Teshome & Oumer, 2023; Okolie et al., 2019).

Narrower gaps in Institutes of Technology (IoTs) likely arise from their specialized, practice-focused governance, superior industry linkages, and emphasis on applied learning compared with conventional models (Figure 11). These institutional contrasts illustrate the promise of technology-centric structures to improve alignment with labor-market demands, pointing toward scalable advantages through broader IoT adoption (Teshome & Oumer, 2023; Okolie et al., 2019).

Lower median gaps and reduced variability in IoTs indicate that specialized institutional designs more effectively synchronize engineering training with employer expectations via better facilities, partnerships, and applied curricula (Figure 12). Conventional frameworks display greater inconsistency and misalignment, emphasizing structural impacts on skill formation. Expanding IoT-inspired approaches could substantially alleviate national employability shortfalls (Teshome & Oumer, 2023; Okolie et al., 2019).

Heavy reliance on lecture-based instruction, coupled with limited project-oriented and industry-engaged methods, drives ongoing skills deficits across Ethiopian engineering programs (Figure 13). IoTs show marginally more progressive practices owing to their applied ethos, yet meaningful deficiencies persist in both models. Shifting decisively toward experiential, practitioner-involved delivery is critical for meaningful improvement (Teshome & Oumer, 2023; Okolie et al., 2019).

a. Limitations

This study is constrained by its reliance on self-reported survey data from graduates, employers, and instructors, which may introduce response bias, social desirability effects, and recall inaccuracies. The sample is limited to selected Ethiopian universities and does not fully represent all engineering programs nationwide. Cross-sectional design precludes causal inference regarding pedagogical or institutional factors and skills gaps. Quantitative focus limits in-depth exploration of contextual socio-cultural barriers, resource constraints, and implementation challenges. External validity may be affected by rapid policy and economic changes post-data collection.

b. Future Directions

Future research should adopt longitudinal tracer studies tracking graduate employment outcomes over 3–5 years to establish causal links between pedagogical reforms and labor-market success. Mixed-methods designs incorporating qualitative interviews and classroom observations would better capture implementation barriers and enablers. Comparative analyses across more African contexts could identify transferable best practices. Experimental interventions testing project-based, industry-engaged curricula in pilot IoT and conventional programs are recommended. Finally, integrating digital learning platforms and continuous employer feedback loops could enhance real-time curriculum alignment and relevance.

V. Conclusion

5.1. Conclusions

This study reveals persistent and substantial misalignment between the competencies of engineering graduates in Ethiopia and the expectations of employers across civil, electrical, mechanical, and chemical engineering disciplines. Graduates self-assess their readiness at moderate levels (approximately 3.1–3.5 on a 5-point scale), while employers consistently demand high proficiency (4.4–4.8), resulting in mean gaps of 1.1–1.7 points, most pronounced in technical skills, discipline-specific knowledge, and generic technical competencies. Interpersonal and communication skills exhibit comparatively smaller disparities, indicating relative strength in soft-skill development within current curricula.

Perceptual differences among stakeholders are statistically significant, particularly in technical and generic domains, where employers diverge markedly from the closer alignment observed between graduates and instructors. This pattern underscores a fundamental disconnect between academic self-evaluation and industry requirements.

Institutionally, Institutes of Technology (IoTs) demonstrate modestly but consistently smaller skills gaps and less variability than conventional university structures across all competency domains. The narrower gaps in IoTs are associated with somewhat lower reliance on lecture-based instruction, modestly higher adoption of project/problem-based learning, and stronger (though still limited) integration of industry practitioners in curriculum delivery.

Pedagogically, Ethiopian engineering programs remain heavily dominated by traditional lecture-based methods (mean prevalence 3.7–4.3), with insufficient emphasis on active, experiential, and problem-oriented approaches (mean extent 2.7–3.4) and very limited involvement of practicing engineers (mean integration 2.1–3.0). These structural and delivery characteristics are major contributors to the observed skills deficits, particularly in applied technical and discipline-specific domains.

Overall, the findings confirm that systemic curriculum-industry misalignment, pedagogical conservatism, and institutional design differences collectively undermine graduate employability and constrain the contribution of engineering education to Ethiopia's industrialization and economic transformation agenda. While incremental advantages exist in specialized IoT frameworks, the magnitude of gaps across all institution types signals that current higher education practices fall short of producing work-ready engineering professionals at scale. Addressing these structural, pedagogical, and perceptual mismatches is essential for aligning tertiary engineering output with national development priorities. (345 words)

5.2 Recommendations

Higher education institutions should urgently transition from lecture-dominant delivery toward active, project-based, and problem-oriented pedagogies, allocating at least 40% of contact hours to hands-on, real-world engineering projects.

Universities must systematically integrate industry practitioners into curriculum design, delivery, and assessment through guest lectures, co-taught modules, internships, and capstone supervision, targeting a minimum of 15–20% practitioner involvement.

The Ministry of Education and university leadership should prioritize scaling the Institute of Technology model nationwide, incorporating its applied orientation, enhanced laboratory infrastructure, and industry linkage mechanisms into conventional structures.

Targeted capacity-building programs for faculty are essential, focusing on modern pedagogical methods, industry engagement, and project supervision skills.

Public–private partnerships should fund shared laboratories, industry-sponsored design challenges, and graduate tracer studies to generate longitudinal evidence for iterative improvement. Finally, policy incentives, such as performance-based funding tied to graduate employment rates and employer satisfaction, should be introduced to accelerate systemic reform and ensure engineering education effectively supports Ethiopia's industrial and technological ambitions.

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