Horn of Africa Journal of Social Science Volume 4 No. 1, 2026 PP. 1 - 18 ISSN:2959 -9156

Adaptation Level of Internet of Things (IoT) in University Curricula: A Case Study on Mogadishu-Located Universities

Said Deq Esse, Abdullahi Mohamud Sharif
Baacil Institute for Research and Devellopment
https://baacil.com

DOI: https://doi.org/10.70806/7qc0zd75

Abstract

The Internet of Things (IoT) is transforming industries globally, yet its integration into university curricula in developing and post-conflict contexts such as Somalia remains largely unexplored. This study examines the adaptation level of IoT within university curricula across 24 institutions in Mogadishu, Somalia, drawn from 56 contacted universities out of more than 120 higher education institutions registered in Somalia. A mixed-methods design combines systematic curriculum document analysis with thematic analysis of open-ended questionnaire data collected from six academic staff members (P1–P6). Findings reveal that only one institution (4.2%) offers IoT as a standalone subject, while all 24 sampled universities (100%) incorporate at least one IoT-related course. Thirteen distinct IoT-related subjects were identified, with Data Communication & Networking and Wireless & Mobile Computing being the most prevalent. Curriculum mapping against IoT architecture layers demonstrates that the network layer is most extensively covered (91.7%), while the application and cloud layer remains critically underrepresented (20.8%). Qualitative thematic analysis identifies infrastructure deficits (100%), curriculum overcrowding (83.3%), funding constraints (50%), and faculty shortages (33.3%) as principal barriers, while documenting a unanimous consensus on the need for IoT integration, high student interest, and an observable trend of students self-enrolling in external IoT training centers to bridge the institutional curriculum gap. The study contextualises findings within East African Community (EAC), Intergovernmental Authority on Development (IGAD), and Arab regional frameworks and concludes that Mogadishu universities possess meaningful curricular foundations but require strategic infrastructure investment, faculty development, and national policy coordination to advance toward dedicated IoT education programs.

Keywords: Internet of Things (IoT), higher education, curriculum integration, Mogadishu, Somalia, mixed-methods, EAC, IGAD, Arab League

Introduction

The Internet of Things (IoT), broadly defined as an interconnected network linking humans to physical objects and enabling machine-to-machine communication (Du et al., 2021), has become a central pillar of national development agendas and industrial transformation worldwide. As IoT technologies penetrate virtually every economic sector—including healthcare, smart cities, manufacturing, and agriculture—the demand for graduates equipped with IoT competencies has grown exponentially, with industry projections suggesting that demand for IoT talent will outpace supply by a factor of five (Raikar et al., 2018). In response, universities globally have begun to introduce IoT Engineering as either a standalone major or a specialized track within Computer Science and Electronic Engineering programs (Wang et al., 2024).

Adapting traditional curricula to accommodate IoT is inherently complex. IoT is an interdisciplinary field requiring the convergence of computer science, communication engineering, embedded electronics, and social sciences, and current adaptation models range from "full coverage" approaches that address all IoT architecture layers to "biased coverage" models that prioritize existing institutional competencies (Du et al., 2021; Koo, 2015). Many institutions, particularly those in developing and post-conflict contexts, face compounding obstacles including unsystematic curricula, deficient practical training infrastructure, shortages of specialized faculty, and inadequate funding (Raikar et al., 2018; Wang et al., 2024; Hendrawati, 2025).

In Somalia, according to the Ministry of Education, Culture and Higher Education, more than 120 universities are currently registered, with the majority concentrated in Banadir State. Of these registered institutions, 56 universities were formally contacted and invited to participate in this study. Due to challenges characteristic of post-conflict research environments—including restricted institutional access, limited administrative transparency, and reluctance to share official curriculum documentation—complete and verifiable curriculum data were ultimately obtained from only 24 institutions (Mohamed, 2023). This access constraint, rather than representing a sampling limitation, itself constitutes empirical evidence of the governance fragmentation that characterizes Somali higher education. Despite the foundational work of Elmi (2024) on IoT's transformative potential for Somalia's education sector, empirical evidence specifically assessing IoT integration at the curriculum level across Mogadishu universities has not previously been generated.

This study addresses that gap by conducting a systematic mixed-methods investigation of IoT curriculum adaptation across 24 sampled universities. The findings are intended to inform strategic capacity building, guide curriculum reform, and support evidence-based policy formulation for the Somali higher education sector and comparable EAC, IGAD, and Arab regional contexts.

Literature Review

The integration of IoT into higher education curricula has emerged as a critical focus area in engineering and computing education research globally. As IoT technologies continue to disrupt industries and reshape labor markets, the imperative for universities to produce graduates with relevant IoT competencies has intensified. This chapter synthesizes existing literature on global IoT curriculum trends, pedagogical models, implementation challenges, and the specific conditions facing EAC, IGAD, Arab regional, and post-conflict developing contexts.

Global Trends in IoT Curriculum Integration

Du et al. (2021) conducted a comprehensive survey of IoT engineering education in Chinese universities, identifying two dominant curriculum models: full coverage, which integrates all IoT architecture layers from sensing and hardware through network connectivity to cloud and application development, and biased coverage, which leverages existing institutional strengths. Their findings indicate that the most effective programs ensure learner competency across all layers regardless of the chosen emphasis. In the United States and Europe, Burd et al. (2018) identified wide variation in IoT content structure, emphasizing that IoT's inherently interdisciplinary nature demands coordinated collaboration between computer science, engineering, information technology, and social science faculties. Programs that established cross-departmental curriculum committees demonstrated significantly more coherent and comprehensive IoT integration. A PRISMA-based systematic review by Fernández-Batanero et al. (2024) of IoT adoption in higher education noted that the overwhelming majority of published studies originate in Europe and Asia, with Africa represented by only one country (Egypt)—underscoring a critical geographic gap in the literature that the present study seeks to partially address.

Within the EAC regional context, the most significant institutional development in IoT higher education is the African Center of Excellence in Internet of Things (ACEIoT), established at the University of Rwanda under World Bank financing through the Eastern and Southern Africa Higher Education Centers of Excellence (ACE II) Project. ACEIoT offers dedicated postgraduate programs in IoT—the Master of Science in IoT-Embedded Computing Systems (MSc. IoT-ECS) and the Master of Science in IoT-Wireless Intelligent Sensor Networking (MSc. IoT-WISeNet)—and explicitly targets students from EAC partner states including Kenya, Ethiopia, Tanzania, Uganda, and Burundi, with preferential scholarship arrangements for EAC nationals (ACEIoT, 2024; ACE II Project, 2022). This regional initiative represents the most advanced institutionalization of dedicated IoT higher education within the geographical community to which Somalia has applied for membership, and stands in sharp contrast to the predominantly fragmented, course-embedded IoT exposure documented in this study.

In Kenya, Letting and Mwikya (2020) conducted a qualitative literature review examining IoT's potential contribution to higher education quality, finding that Kenyan universities face structural challenges in IoT adoption including high content demand, insufficient lecture capture infrastructure, and inadequate internet bandwidth—challenges that parallel those identified in the Somali context. The iLabAfrica research unit at Strathmore University (Kenya) has documented active IoT research infrastructure including LoRaWAN deployments, LPWAN technology development, and multi-institutional collaboration across Kenya, Tanzania, Uganda, and Rwanda, signaling a regional technology ecosystem that could serve as both a benchmark and a potential partnership pathway for Somali institutions (iLabAfrica, 2024). A systematic literature review by Kassab et al. (2020) provided a global synthesis of IoT in education, cataloguing smart classrooms, intelligent attendance systems, and personalized learning environments as primary IoT application domains, while identifying security, scalability, and humanization as overarching implementation challenges.

Curriculum Models and Pedagogical Best Practices

Raikar et al. (2018) demonstrated that project-based learning anchored in real-world IoT applications—including environmental monitoring and smart agriculture—significantly enhances student engagement and practical skill acquisition, underscoring that hands-on laboratory experience is constitutive rather than merely supplementary to effective IoT education. Wang et al. (2024) emphasized that sustainable IoT curricula must be built on student-centered, output-oriented, and continuous improvement principles. Koo (2015) proposed a layered curriculum architecture that progressively develops student competency from foundational digital systems and networking through embedded systems and communication protocols to advanced cloud platforms, analytics, and security—a model that provides a benchmark against which Mogadishu offerings can be assessed.

Within the Arab world—a regional grouping to which Somalia is formally affiliated through the Arab League—Masadeh and El-Haggar (2024) examined factors influencing IoT adoption in Saudi Arabian higher education institutions using an extended Technology Acceptance Model (TAM), identifying knowledge sharing, mobility, interactivity, innovativeness, training, and virtual reality as significant determinants of student behavioral intention toward IoT adoption. Their study documents that even in a relatively resource-rich Arab context, IoT integration faces significant behavioral and organizational barriers beyond infrastructure alone. Ali et al. (2023) proposed an IoT adoption model for e-learning in Saudi Arabia that categorizes influencing factors into individual, organizational, environmental, and technological dimensions—a framework applicable to the Somali context. Aloufi et al. (2024) investigated IoT integration from teachers' perspectives in the Arab world, reporting that teachers acknowledge IoT's educational value but face significant skill gaps and infrastructural barriers, directly resonating with the faculty capacity and infrastructure themes emerging from this study. Derbas et al. (2025) investigated student-perspective IoT integration challenges at Al-

Zaytoonah University of Jordan, documenting that inadequate infrastructure, low faculty expertise, and the absence of structured IoT curricula are the primary obstacles—a pattern that closely mirrors findings from the Saudi and Somali contexts alike.

Challenges to IoT Curriculum Integration

A consistent finding across the literature is that institutional willingness alone is insufficient to achieve meaningful IoT integration. Koo (2015) cautions against superficial curricula that merely relabel existing courses without building genuine cross-layer competency, leaving graduates unable to integrate components into functional IoT systems. Raikar et al. (2018) highlight the persistent infrastructure deficit in developing-country institutions, where the absence of well-equipped IoT laboratories severely constrains hands-on learning. Wang et al. (2024) identify faculty shortages as a critical systemic barrier, recommending structured faculty development through industry partnerships and professional certification programs.

Hendrawati (2025) draws attention to institutional culture as a frequently underestimated integration challenge: low technological literacy and resistance to curriculum change can impede even technically well-resourced programs. Madni et al. (2022), in a multi-country study of IoT e-learning adoption in developing countries including Saudi Arabia, Malaysia, Pakistan, and Bangladesh, found that individual, organizational, environmental, and technological factors each act as independent adoption constraints, confirming that IoT integration is a multi-dimensional challenge not reducible to infrastructure alone. Fernández-Batanero et al. (2024) confirmed that adoption challenges cluster around hardware/connectivity infrastructure, institutional policy frameworks, faculty training, and student readiness—a fourfold typology directly mapping onto this study's thematic findings.

Within the IGAD sub-regional context, Ethiopia exemplifies the digital transformation challenges facing comparable post-conflict and low-resource higher education systems. Research documents that infrastructure deficits, inadequate broadband connectivity, and the absence of enabling regulatory directives have constrained ICT integration even in public universities, despite national development plans that explicitly foreground digital transformation as a strategic priority (Ferede et al., 2022). Nigeria presents a similar pattern as Onayinka (2024) documented that Nigerian universities have identified IoT as a strategic educational technology but face infrastructure, expertise, and resource constraints that closely parallel those observed in Mogadishu. These comparative regional findings situate Somalia's IoT curriculum challenges within a broader pattern of structurally constrained digital education development across the IGAD and EAC regional architecture, underscoring the value of coordinated regional policy responses.

IoT Integration in the Somali Context

Research specifically addressing IoT in the Somali higher education context remains limited. Elmi (2024) conducted a foundational study on the transformative potential of IoT for educational outcomes in Somalia, identifying a growing youth population with interest in technology, increasing mobile connectivity, and IoT's applicability to local challenges in healthcare and agriculture as opportunities, alongside structural barriers including limited infrastructure, unreliable electricity supply, shortage of trained faculty, slow curriculum revision, and limited industry-academia linkages. Elmi proposed a phased IoT implementation model involving infrastructure assessment, pilot device deployment, faculty capacity building, and systematic curriculum integration. The present study extends this foundational work by providing the first empirical, curriculum-level evidence base for IoT adaptation across Mogadishu's university sector.

Methodology

This study employed a mixed-methods research design, integrating quantitative curriculum document analysis with qualitative thematic analysis of open-ended questionnaire data. The mixed-methods approach enables a more complete and nuanced understanding of IoT adaptation than either method alone could provide (Creswell & Creswell, 2018).

Study Context and Population

The study was conducted in Mogadishu, the administrative and academic center of Somalia. According to the Ministry of Education, Culture and Higher Education, more than 120 universities are currently registered in Somalia, with the majority located in Banadir State. These institutions operate under diverse ownership models—public and private—with considerable variation in academic standards and infrastructure capacity. Of these registered institutions, 56 universities were formally contacted as the reachable study population.

Sample Selection and Justification

All 56 contacted universities were formally invited to share curriculum documentation. Complete and verifiable curriculum data were ultimately obtained from 24 institutions (42.9% response rate), which constituted the final analytical sample. The reduced sample reflects systemic access constraints—restricted institutional access, limited administrative transparency, and reluctance to share curriculum documentation—characteristic of post-conflict research environments (Mohamed, 2023), rather than methodological sampling bias.

Data Collection Instruments and Procedures

Two complementary data collection methods were employed. First, systematic curriculum document analysis was conducted using official degree structures, course outlines, and subject descriptions provided by each participating institution. The analysis focused on: (a) identifying the presence or absence of IoT as a standalone subject; (b) cataloguing all IoT-related subjects embedded within computing and technology programs; and (c) mapping identified subjects against the three recognized IoT architecture layers (perception/hardware, network, and application/cloud).

Second, open-ended questionnaires were administered in January 2026 to six academic staff members (designated P1–P6) actively engaged in teaching technology-related subjects and curriculum development. The questionnaire instrument is presented in Table 1.

Table 1. Questionnaire Sections and Corresponding Questions

Section	Question
Curriculum Issues	Why is Internet of Things (IoT) not currently offered as a standalone subject in your university curriculum?
Infrastructure, Faculty Gaps, and Funding Problems	What are the major challenges or barriers that prevent universities from offering IoT as part of their curriculum?
Readiness Assessment	Do you believe IoT should be included in the university curriculum? Please explain your reasons. Do you think universities have basic facilities or resources that could support IoT teaching and practical work? Based on your experience, do students show interest in learning IoT-related skills?

Data Analysis Procedures

Quantitative data were analyzed using descriptive statistics, including frequency counts and percentages. Subjects were classified as either IoT subjects (standalone) or IoT-related subjects (embedded) and mapped onto IoT architecture layers to assess coverage depth. Qualitative data were analyzed using the six-phase thematic analysis framework of Braun and Clarke (2006): familiarization, initial coding, theme search, theme review, theme definition, and report generation. Methodological triangulation of documentary and qualitative data strengthens the credibility and contextual validity of the findings.

Results

Results are organized into two subsections: quantitative findings from curriculum document analysis, and qualitative findings from thematic analysis of academic staff questionnaire responses.

Curriculum Document Analysis

Availability of IoT as a Standalone Subject

As shown in Table 2, only one university (4.2%) offers IoT as a standalone subject, while 23 institutions (95.8%) do not. Despite this near-total absence of standalone programs, all 24 universities (100%) include at least one IoT-related subject within their computing or IT curricula.

Table 2. Availability of IoT as a Standalone Subject

IoT Program Availability	n (%)
IoT Offered as Standalone Subject	1 (4.2%)
No Standalone IoT Subject	23 (95.8%)

IoT-Related Subjects Identified in Curricula

Thirteen distinct IoT-related subjects were identified across the 24 sampled universities, as presented in Table 3. Data Communication & Networking was the most prevalent, offered by 9 universities (37.5%), followed by Wireless & Mobile Computing (8 universities; 33.3%) and Microprocessor Systems (7 universities; 29.2%). Advanced Network, Digital Electronics, and Cloud Computing were each present in 4 institutions (16.7%). Computier Neworking was present in 3 universities (12.5%). The remaining six subjects appeared in only one institution each (4.2%), reflecting limited specialization.

Table 3. IoT-Related Subjects Identified in University Curricula

No.	IoT-Related Subject	n (%)
1	Data Communication & Networking	9 (37.5%)
2	Wireless & Mobile Computing	8 (33.3%)
3	Microprocessor Systems	7 (29.2%)
4	Advanced Network	4 (16.7%)
5	Digital Electronics	4 (16.7%)
6	Cloud Computing	4 (16.7%)
7	Computer Networking	3 (12.5%)
8	Internet Technology	1 (4.2%)
9	Introduction to Networking	1 (4.2%)
10	Digital Logic Design	1 (4.2%)
11	Embedded Systems	1 (4.2%)
12	Advanced Data Communication & Network	1 (4.2%)
13	Telecommunication	1 (4.2%)

Availability of Dedicated IoT Degree Programs

Table 4 confirms that no university offers a Bachelor's Degree or Certificate/Diploma specifically in IoT. One institution (4.2%) offers an IoT-related specialization within an existing program, while 23 (95.8%) have no dedicated IoT degree pathway. IoT education in Mogadishu therefore remains fragmented, with students acquiring IoT-relevant competencies through isolated subjects within broader computing programs.

Table 4. Availability of Dedicated IoT Degree Programs

Degree Level	n (%)
Bachelor's Degree in IoT	0 (0%)
Specialization/Track in IoT	1 (4.2%)
Certificate/Diploma in IoT	0 (0%)
No Dedicated IoT Degree Program	23 (95.8%)

Distribution of IoT-Related Subjects by Year of Study

Table 5 map the distribution of IoT-related subjects across academic year levels. Year 3 exhibits the highest density, with 7 subjects offered across 91.7% of universities. Years 1–2 cover 5 foundational subjects in 75% of institutions. Year 4 presents a sharp and counterintuitive decline, with only 6 subjects—

including the most advanced topics such as Cloud Computing, Embedded Systems, and IoT—offered by only 41.7% of universities. This structural regression at the final year suggests curriculum compression driven by resource and faculty constraints.

Table 5. Distribution of IoT-Related Subjects by Year of Study

Year Level	Subjects Offered	n (%)
Year 1–2	Digital Electronics, Digital Logic Design, Introduction to Networking, Microprocessor Systems, Data Communication & Networking	5 (75.0%)
Year 3	Data Communication & Networking, Wireless & Mobile Computing, Advanced Network, Computer Networking, Microprocessor Systems, Assembly Language, Internet Technology	7 (91.7%)
Year 4	Wireless & Mobile Computing, Cloud Computing, Embedded Systems, IoT, Advanced Data Communication & Network, Telecommunication	6 (41.7%)

Note. Semesters 1–4 = Years 1–2; Semesters 5–6 = Year 3; Semesters 7–8 = Year 4.

Mapping Subjects to IoT Architecture Layers

Table 6 map subjects onto the three canonical IoT architecture layers following Du et al. (2021) and Koo (2015). The network layer is most extensively covered, with 22 universities (91.7%) offering relevant subjects. The perception/hardware layer receives moderate coverage at 11 universities (45.8%). The application and cloud layer is critically underrepresented, with only 5 universities (20.8%) providing relevant instruction. This imbalance—the signature finding of the quantitative analysis—indicates that graduates from most Mogadishu universities lack the upper-layer competencies required for end-to-end IoT system design and deployment.

Table 6. Mapping of IoT-Related Subjects to IoT Architecture Layers

IoT Architecture Layer	Corresponding Subjects	n (%)
Perception / Hardware Layer	Microprocessor Systems, Digital Electronics, Digital Logic Design, Embedded Systems	11 (45.8%)
Network Layer	Data Communication & Networking, Advanced Network, Internet Technology, Introduction to Networking, Computer Networking, Wireless & Mobile Computing, Telecommunication	22 (91.7%)
Application / Cloud Layer	Cloud Computing, Advanced Data Communication & Network	5 (20.8%)

Note. A university is counted for a layer if at least one corresponding subject appears in its curriculum.

Distribution of Universities by Number of IoT-Related Subjects

Table 7 presents the distribution of universities by total number of IoT-related subjects. The majority—19 universities (79.2%)—offer exactly two IoT-related subjects, indicating shallow and standardized integration. Four universities (16.7%) offer only one subject. Only one institution (4.2%) offers three.

Table 7. Distribution of Universities by Number of IoT-Related Subjects Offered

No. of IoT-Related Subjects	Institutions (%)
1 subject	4 (16.7%)
2 subjects	19 (79.2%)
3 subjects	1 (4.2%)

Thematic Analysis of Academic Staff Perspectives

Thematic analysis of open-ended questionnaire responses from six academic staff members (P1–P6) yielded seven salient themes, summarized in Table 8 with response frequencies. Representative responses are presented in Table 9.

Table 8. Alignment of Interview Questions and Qualitative Themes

Interview Question	Theme Identified	Response Frequency
Why is IoT not offered as a standalone subject?	Curriculum Integration Issues	5/6 (83.3%)
What are the major challenges or barriers?	Infrastructure Deficits	6/6 (100%)
	Funding Constraints	3/6 (50.0%)
	Faculty Capacity Gaps	2/6 (33.3%)
Should IoT be included in the curriculum?	Unanimous Support for IoT Integration	6/6 (100%)
Do universities have basic facilities for IoT?	Complete Absence of Basic IoT Facilities	6/6 (100%)
Do students show interest in IoT skills?	High Student Interest in IoT	6/6 (100%)

Table 9. Representative Respondent Responses by Theme

Code	Theme / Sub-theme	Summarized Response
P1	Curriculum Overload / Embedded IoT	*IoT concepts are currently integrated within existing courses due to curriculum load constraints. Students*

Code	Theme / Sub-theme	Summarized Response
		show strong interest, evidenced by IoT topics in graduation theses and enrolment in external training centers.
P2	Lab Scarcity / Embedded Chapters	*IoT is included as chapters in the syllabus; establishing labs and equipment is the primary prerequisite for any dedicated offering.*
P3	Overcrowded Curriculum / No Facilities	*The curriculum is already overloaded with core subjects. Universities generally do not have sufficient IoT labs or practical facilities at this time.*
P4	Resource and Experience Shortage	*Limited funding, equipment, and experience are the core challenges. Faculties are insufficient in number.*
P5	Outdated Curriculum / Infrastructure	*Older curriculum versions remain in use; infrastructure is the main barrier to change.*
P6	Multi-barrier Context	*IoT is absent due to limited infrastructure, equipment, unreliable internet and electricity, and curricula still focused mainly on basic subjects. Students are excited and recognize IoT job market value.*

Theme 1: Curriculum Integration Issues (5/6; 83.3%)

Five respondents identified curriculum integration issues as the primary driver of IoT's absence as a standalone subject. P3 stated that the existing curriculum is already overloaded with core subjects, resulting in IoT content being embedded within Assembly Language and Microprocessor courses rather than taught independently. P1 similarly attributed IoT's integration to curriculum load constraints. P2 described IoT content as included as chapters within existing syllabi. These responses reveal a structural design tension between the breadth of foundational computing coverage and the specialist depth increasingly demanded by the technology labor market. Importantly, this theme—curriculum overcrowding—is distinct from and additional to the infrastructure deficit theme: even if hardware were available, the absence of curriculum space would independently prevent standalone IoT provision.

Theme 2: Infrastructure Deficits (6/6; 100%)

All six respondents identified infrastructure limitations as the most significant barrier. Specific deficits cited include unreliable internet connectivity and electricity (P6), insufficient hardware including sensors, microcontrollers, and development kits (P2, P4, P6), and the complete absence of dedicated IoT laboratories (P2, P3, P5, P6). P3 confirmed that universities generally do not have sufficient IoT labs or practical facilities at this time. P6 provided the most comprehensive barrier inventory: lack of resources and modern equipment, inadequate infrastructure and laboratories, limited funding, unreliable internet and electricity, and curricula still focused mainly on foundational subjects. Only P1 suggested that most universities already have basic resources that can be adapted—likely referring to general computing infrastructure rather than IoT-specific equipment—a divergence from the other five respondents that warrants further investigation.

Theme 3: Funding Constraints (3/6; 50%)

Three respondents (P1, P4, P6) identified financial constraints as a major barrier, encompassing hardware acquisition costs, absence of dedicated laboratory development budgets, and limited access to international funding or industry sponsorship. P4 summarized succinctly: limited funding, equipment, and experience are the core challenges. Respondents consistently framed funding as the enabling prerequisite for infrastructure development, indicating that financial investment is the causal mechanism through which all other structural barriers might be addressed.

Theme 4: Faculty Capacity Gaps (2/6; 33.3%)

Two respondents (P4, P6) identified a shortage of faculty with specialized IoT expertise. While less frequently cited than infrastructure and funding concerns, this theme is strategically significant: even where physical resources might be made available, the absence of adequately trained instructors would constitute a binding constraint on instructional quality and program credibility. This is consistent with Wang et al.'s (2024) identification of faculty shortage as a critical systemic barrier, and with Aloufi et al.'s (2024) documentation of teacher skill gaps as an independent obstacle to IoT integration in the Arab higher education context.

Theme 5: Unanimous Support for IoT Integration (6/6; 100%)

All six respondents unequivocally affirmed that IoT should be integrated into university curricula. Justifications clustered around four sub-arguments: IoT as a modern technology of intrinsic educational value (P2, P5); its alignment with labor market demands (P1, P3, P4); its potential to drive innovation and research (P6); and its applicability to local development challenges in health, manufacturing, and agriculture (P2, P6). This unanimity signals strong academic will in attitudinal terms, even where structural preconditions remain unmet, and directly contradicts any interpretation that absence of IoT programs reflects faculty indifference.

Theme 6: Complete Absence of Basic IoT Facilities (6/6; 100%)

All respondents confirmed the complete or near-complete absence of basic IoT facilities. Five directly responded "no" to the question of whether universities have basic resources to support IoT teaching and practical work. The single partial exception (P1) suggested that existing computing resources could be adapted, but this was framed conditionally and not corroborated by other respondents. This near-universal infrastructure void constitutes the primary operational bottleneck for curriculum advancement and the clearest actionable priority for any institutional or national intervention.

Theme 7: High Student Interest with Self-Directed Learning (6/6; 100%)

All six respondents reported high levels of student interest in acquiring IoT-related skills. Critically, P1 provided evidence of active student-driven learning as students have chosen to include IoT topics in graduation theses within a Bachelor of Computer Science program, and are actively enrolling in external IoT training centers outside the university to acquire practical skills unavailable within their degree programs. P3 observed that interest is particularly pronounced when students are exposed to practical or real-world applications. P6 noted that students are excited by modern technologies and recognize IoT's job market value. The existence of self-directed, externally-funded IoT learning is a particularly significant new finding: it indicates that student demand is not passive but active, with students investing personal resources to bridge the curriculum gap. This repositions the readiness gap as one of institutional capacity rather than student motivation, and has direct implications for policy: formal credit recognition frameworks for external IoT certifications could harness this existing student momentum at minimal institutional cost.

Discussion

The findings of this study reveal that IoT curriculum adaptation in Mogadishu universities is nascent, structurally limited, and characterized by a pronounced gap between institutional ambition and operational capacity. The quantitative and qualitative evidence together point to a higher education ecosystem that has established meaningful curricular foundations but has not yet developed the infrastructure, policy frameworks, or faculty capacity required to translate those foundations into coherent and practice-oriented IoT programs.

The universal presence of IoT-related subjects confirms that Mogadishu universities are not starting from scratch. However, the overwhelming concentration of institutions offering only one or two IoT-related subjects (96% of the sample), combined with the near-total absence of standalone IoT programs, indicates that this foundation has not been strategically organized into the coherent, layered curricular architecture recommended by Koo (2015) and Wang et al. (2024). The IoT architecture layer analysis provides the most diagnostically precise finding: the dramatic imbalance between network layer coverage (91.7%) and application/cloud layer coverage (20.8%) reveals that current curricula equip students with strong foundational connectivity knowledge but fail to develop the higher-order competencies—system integration, cloud deployment, application development—that characterize professional IoT practice. This mirrors the "biased coverage" pattern identified by Du et al. (2021) in a Chinese context, but without the intentional strategic rationale.

The year-level distribution analysis reveals a counterintuitive structural anomaly: advanced IoT content declines sharply in Year 4 (41.7%) compared to Year 3 (91.7%), at precisely the academic stage where the most specialist IoT instruction logically belongs. This is symptomatic of the resource and faculty constraints documented qualitatively: where institutions lack IoT laboratory infrastructure and faculty expertise, advanced IoT modules cannot be effectively delivered regardless of their presence in formal curriculum documents.

The qualitative findings introduce two dimensions. First, the thematic analysis reveals important nuances within the infrastructure deficit theme: one respondent (P1) suggested that existing general computing resources could be adapted, distinguishing between the absence of dedicated IoT hardware (unanimously confirmed) and the question of whether existing infrastructure could support introductory IoT instruction—a distinction with practical implications for a phased implementation strategy. Second, the discovery that students are actively self-enrolling in external IoT training centers and incorporating IoT topics into graduation theses significantly extends the findings: student demand is not passive but active, with students investing personal resources to bridge the institutional curriculum gap. This repositions the nature of the IoT readiness gap from a motivational deficit to a structural and institutional one, and suggests that formal credit recognition frameworks for external IoT certifications could rapidly and cost-effectively harness existing student momentum.

Comparative contextualization within EAC, IGAD, and Arab regional frameworks further illuminates these findings. Within the EAC, Rwanda's ACEIoT represents a model of IoT education institutionalization—leveraging World Bank financing, inter-university coordination, and dedicated postgraduate program design—that contrasts sharply with the fragmented pattern documented in Mogadishu, and provides a concrete regional partnership model for Somali institutions to emulate. Within the Arab regional grouping, studies from Saudi Arabia, Jordan, and the broader Arab world reveal remarkably similar patterns of nascent IoT education constrained by infrastructure, faculty capacity, and policy gaps (Masadeh & El-Haggar, 2024; Derbas et al., 2025; Aloufi et al., 2024), suggesting that coordinated regional curriculum framework development through ALECSO or comparable bodies could generate shared resources of direct value to Somalia. Within the IGAD framework, the parallels with Ethiopia's digital transformation challenges (Ferede et al., 2022) and Nigeria's IoT education barriers (Onayinka, 2024) further confirm that Mogadishu's challenges are structurally typical of the regional context rather than uniquely Somali.

Conclusion

This study provides the first empirical, curriculum-level assessment of IoT adaptation across Mogadishu universities, drawing on data from 24 institutions out of 56 contacted. The core finding is that IoT integration is progressing but remains structurally shallow, institutionally fragmented, and constrained by infrastructure deficits and policy voids.

The study makes five principal contributions. First, it establishes a quantitative baseline for IoT curriculum integration in Somali higher education. Second, it introduces IoT architecture layer mapping as an analytical tool that reveals a critical underrepresentation of application/cloud layer education not apparent from subject-count analyses alone. Third, it identifies the counterintuitive Year 4 decline in advanced IoT content as a diagnostic indicator of structural curriculum compression. Fourth, it documents—for the first time—active student self-directed IoT learning through external training centers, repositioning the readiness gap as structural rather than motivational. Fifth, it contextualises the Somali case within EAC, IGAD, and Arab regional frameworks, identifying comparative models and concrete partnership pathways.

The pathway to sustainable IoT education in Mogadishu does not require starting from scratch. It requires the strategic organization of existing curricular assets into coherent, layer-balanced programs, supported by targeted infrastructure investment, structured faculty development, formal recognition of student external certifications, and a national policy framework developed in dialogue with EAC, IGAD, and Arab regional bodies that already possess relevant expertise and financing instruments.

Recommendations

Based on the findings of this study, the following recommendations are directed at specific stakeholders:

1. Structured IoT Curriculum Development: Universities should map existing IoT-related subjects against the three IoT architecture layers and develop structured, layer-balanced pathways—particularly addressing the critical underrepresentation of application/cloud layer content—in alignment with national ICT strategies.
2. Phased Laboratory Establishment: Priority investment should be made in IoT hardware kits, sensor arrays, and microcontroller development boards. As an interim step, existing computing laboratories—identified by P1 as potentially adaptable—should be assessed for minimum-cost repurposing to support introductory IoT experimentation.
3. Faculty Capacity Building: Structured professional development programs, including workshops, online certifications, and industry mentorships, should be introduced. Faculty development is a prerequisite for quality-assured IoT program delivery and must accompany, not follow, infrastructure investment.

4. Formal Recognition of External IoT Certifications: Given the documented practice of students independently enrolling in external IoT training centers, Somali National Commission for Higher Education (NCHE) should develop formal credit recognition frameworks for external IoT certifications and industry credentials, harnessing existing student motivation at minimal institutional cost.
5. National IoT Education Policy and Regulatory Framework: The NCHE should develop formal policies, accreditation standards, and ethical guidelines governing IoT program delivery, providing the regulatory foundation for coherent sector-wide advancement.
6. EAC and IGAD Regional Partnership Development: Somali universities should pursue active partnerships with ACEIoT (University of Rwanda) and iLabAfrica (Strathmore University, Kenya) for joint laboratory access, faculty exchange, and curriculum co-development.
7. Arab Regional Cooperation through ALECSO: Through Somalia's Arab League membership, engagement with ALECSO should be pursued to access shared Arab IoT curriculum frameworks and faculty development resources documented in comparative literature from Saudi Arabia and Jordan.
8. National IoT Coordination Body: Establishing a dedicated national body responsible for IoT curriculum standardization, faculty certification, infrastructure benchmarking, and industry-academia linkage could significantly accelerate systemic progress and align advancement with Somalia's broader ICT development priorities.

References

ACE II Project. (2022). *Latest updates and announcements.* Inter-University Council for East Africa. https://ace2.iucea.org

ACEIoT. (2024). *African Center of Excellence in Internet of Things.* University of Rwanda. https://aceiot.ur.ac.rw

Ali, J., Madni, S. H. H., Jahangeer, M. S. I., & Danish, M. A. A. (2023). IoT adoption model for e-learning in higher education institutes: A case study in Saudi Arabia. *Sustainability, 15*(12), 9748. https://doi.org/10.3390/su15129748

Aloufi, F., Tashtoush, M. A., Shirawia, N., Tashtoush, R. A., & Az-Zo'Bi, E. A. (2024). Internet of Things in education: Teachers' perspectives, practices and challenges. *WSEAS Transactions on Computer Research, 12*, 429–442. https://doi.org/10.37394/232018.2024.12.42

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–93. https://doi.org/10.1191/1478088706qp063oa

Burd, B., Barker, L., & Pérez, F. A. F. (2018). The Internet of Things in undergraduate computer and information science education: Exploring curricula and pedagogy. In *Proceedings of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education Companion* (pp. 345–346). ACM. https://doi.org/10.1145/3293881.3295784

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Derbas, A., Hnaif, A., Al-Saleh, S., Al Zyoud, I., & Al-Khawaja, H. A. (2025). Challenges of IoT integration in education: A case study of students at Al-Zaytoonah University of Jordan. *International Journal of Advanced and Applied Sciences, 12*(1), 125–131. https://doi.org/10.21833/ijaas.2025.01.012

Du, B., Chai, Y., Huangfu, W., Zhou, R., & Ning, H. (2021). Undergraduate university education in Internet of Things engineering in China: A survey. *Education Sciences, 11*(5), 202. https://doi.org/10.3390/educsci11050202

Elmi, M. A. (2024). Transforming educational outcomes with IoT: Opportunities and challenges in Somalia. *SSRG International Journal of Electrical and Electronics Engineering, 11*(4), 45–52.

Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & López Meneses, E. (2024). Adoption of the Internet of Things in higher education: Opportunities and challenges. *Interactive Technology and Smart Education, 21*(2), 292–307. https://doi.org/10.1108/ITSE-01-2023-0025

Ferede, B., Schmid, M., Juuti, T., & Lavonen, J. (2022). Digitalization of higher education in Ethiopia. *Education and Information Technologies, 29*, 1–28.

Hendrawati, T. (2025). Integration of IoT devices in PAI learning: Strategic impact on curriculum management, evaluation, and resources. *EDUKASIA: Jurnal Pendidikan dan Pembelajaran, 6*(2).

iLabAfrica. (2024). *Internet of Things and wireless networks.* Strathmore University. https://ilabafrica.strathmore.edu/internet-of-things-and-wireless-networks/

Kassab, M., DeFranco, J., & Laplante, P. (2020). A systematic literature review on Internet of Things in education: Benefits and challenges. *Journal of Computer Assisted Learning, 36*(2), 115–127. https://doi.org/10.1111/jcal.12383

Koo, S. G. M. (2015). An integrated curriculum for Internet of Things: Experience and evaluation. In *Proceedings of the IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)* (pp. 123–128). IEEE.

Letting, N., & Mwikya, J. (2020). Internet of Things (IoT) and quality of higher education in Kenya: A literature review. *Research Journal of Education, Teaching and Curriculum Studies.*

Madni, S. H. H., Ali, J., Husnain, H. A., Masum, M. H., Mustafa, S., Shuja, J., Maray, M., & Hosseini, S. (2022). Factors influencing the adoption of IoT for e-learning in higher educational institutes in developing countries. *Frontiers in Psychology, 13*, 915596. https://doi.org/10.3389/fpsyg.2022.915596

Masadeh, S. A., & El-Haggar, N. (2024). Analyzing factors influencing IoT adoption in higher educational institutions in Saudi Arabia using a modified TAM model. *Education and Information Technologies, 29*, 6407–6441. https://doi.org/10.1007/s10639-023-12039-2

Mohamed, A. A. (2023). A review of curriculum change and innovation for higher education in Somalia. *European Journal of Education Studies, 10*(5). https://doi.org/10.46827/ejes.v10i5.4868

Onayinka, T. S. (2024). Leveraging Internet of Things in 21st century education in Nigeria: Gains, challenges, and future direction. *Gusau Journal of Sociology, 4*(2), 91–102.

Raikar, M. M., Desai, P., & Vijayalakshmi, M. (2018). Upsurge of IoT (Internet of Things) in engineering education: A case study. In *Proceedings of the K.L.E. Technological University Conference.* K.L.E. Technological University.

Wang, H., Yue, X., & Zhang, W. (2024). Constructing an IoT engineering curriculum for engineering education accreditation. In *Proceedings of the Shandong Xiehe University Academic Conference.* Shandong Xiehe University.