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Assessing East Africa Leading Universities' Adherence to Regional and Global Computer Science Curriculum Guidelines

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Abstract: Established universities often lead regional efforts in curriculum innovation and the adoption of emerging academic standards. In East Africa, this trend is exemplified by Makerere University—the region's oldest—alongside the University of Nairobi, Kenyatta University, and the University of Dar es Salaam. This paper examines how the undergraduate computer science programs at these institutions align with the Inter-University Council for East Africa (IUCEA) benchmarks and how they compare with the recently introduced global standards outlined in CS2023. The findings reveal strong convergence between the current Computer Science (CS) programs and CS2023, notable divergence between CS2023 and the IUCEA benchmarks, and statistically significant differences across several institutional programs. The paper demonstrates how CS programs can be systematically mapped to CS2023 standards and how regional coordination can be achieved.

Keywords: CS2023 Computer Science Benchmark, IUCEA Benchmark for CS, CS curricula, Knowledge Areas, Knowledge Units, Competence based models

1. Introduction

The information and communication technology (ICT) sector is a key priority sector for economic development and digital transformation in East Africa. To fully harness the potential of ICT, the need for development of human capital in the core computing disciplines such as Computer Science (CS) including Artificial Intelligence (AI), Information Technology (IT) and Software Engineering (SE) is key [8,10]. In line with the ongoing efforts toward East African regional economic integration, the harmonization of the curricula and training can play a central role in improving the quality of education and enabling mobility of skilled professionals and students across universities.

The Inter-University Council for East Africa (IUCEA) developed regional benchmarks (2015) for the Bachelor of Computer Science (BSc CS) and Bachelor of Information Technology (BSc IT) programs [1]. These benchmarks are intended to promote harmonization, comparability, and quality assurance across East African Community (EAC) universities. A decade later, there is a need to evaluate and quantify the degree to which leading universities have aligned their curricula with these benchmarks. Further, higher education integration and harmonization efforts are expanding across different regions in Africa [8,11,12,13]; therefore, there is a need to systematically study, document, and publish the progress achieved across the region.

For more than a decade, the IEEE/ACM CS2013 [4] curriculum guidelines have served as a foundational reference for CS programs across the world. In recent years, however, rapid developments in the computing landscape, in particular the rise of AI and, most notably, generative AI, have underscored the need to revisit and modernize these guidelines. This shift has demanded a re-examination of how CS is taught and learned, as well as greater emphasis on the social, ethical, and professional implications of computing. These efforts culminated in the publication of the updated IEEE/ACM CS2023 curriculum guidelines in 2024 [2].

This paper adopts a two-pronged approach to reviewing and analyzing how leading EAC universities CS programs align with global curricula standards. First, given the introduction of CS2023, it is essential to examine how the IUCEA CS benchmarks correspond to these global standards. Second, the curricula of selected EAC universities CS programs are mapped onto the combined CS2023/IUCEA Knowledge Areas (KAs) to evaluate the extent of coverage. Finally, the curricula of the universities are compared with one another to assess their level of alignment with both the IUCEA benchmarks and the CS2023 guidelines.

The remainder of this paper is organized as follows. Section 1.1 outlines the objectives of the study, while Section 2 presents a brief literature review and provides an overview of both the IUCEA benchmarks and the CS2023 standards. Section 3 describes the methodology used in the study, while Section 4 provides results and discussion. Finally, Section 5 concludes the paper with recommendations and directions for future work.

1.1 Objectives

The overall aim of this study is to evaluate curriculum alignment and harmonization of CS programs within the EAC. The specific objectives are to:

- Evaluate alignment of IUCEA (2015) CS benchmarks with IEEE/ACM CS2023 guidelines
- Map selected EAC universities' CS curricula onto a combined IUCEA–CS2023 Knowledge Area framework.
- Quantify the extent of curriculum coverage and identify gaps or overlaps.
- Compare alignment levels across leading EAC universities.
- Assess implications for harmonization and quality assurance

2. Literature Survey

Attempts have been made to compare CS education at different levels in Africa [5,6,7,8]. For instance, Bainomugisha et al. [5] examine over 20 years of undergraduate CS education across Kenya, Uganda, Tanzania, South Africa, and Ghana. Their work highlights key challenges and opportunities. Major challenges include limited CS expertise, shortages of qualified teaching staff, and pedagogical gaps. Identified opportunities include secondary school outreach, bridging programs for prospective CS students, and faculty development initiatives. The study by Sanusi and Deriba [6] discovered that the literature on CS education in Africa is dominated by studies from South Africa and has mostly focused on programming, highlighting the need for studies that cover other countries of the continent and other aspects of CS education. Moreover, by investigating the capacity to deliver K-12 computing education curriculum in four African countries (Uganda, Nigeria, Kenya, and Botswana), Tshukudu [7] found that African computing educators experienced more curriculum delivery capacity barriers and focused less on teaching programming and algorithms compared to their counterparts from the developed world. Access to teaching resources and infrastructures was also found to vary across the studied African countries.

Nevertheless, while the existing literature has covered various aspects of computing education in the African context, including the East African region, little is known about whether CS education in higher education institutions in the East African region aligns with regional and global standards. This limits the ability to understand quality assurance aspects as well as the comparability and potential mobility of CS graduates across the East African region. To contribute to filling that void, this paper seeks to (1) assess adherence to IUCEA CS benchmarks across leading East African universities, and (2) analyse the alignment of IUCEA CS benchmark with global ACM CS2023 computing education frameworks. The former is particularly relevant considering ongoing regional integration within the EAC, while the latter reflects the demands of an increasingly interconnected global computing landscape.

The next sections introduce IUCEA CS benchmarks and the CS2023 curricula standards.

2.1 Inter-University Council for East Africa Benchmarks for the bachelor's in computer science and the bachelor's in information technology programs (IUCEA CS Benchmark 2015)

The East African Community (EAC) comprises Uganda, Kenya, Tanzania, Rwanda, Burundi, South Sudan, the Democratic Republic of Congo, and the Federal Republic of Somalia. The EAC is an intergovernmental organization committed to advancing regional integration through a customs union, a common market, a monetary union, and an eventual political federation [9]. The Community operates through seven main organs that drive its mandate: the Summit, the Council of Ministers, the Coordinating Committees, the East African Court of Justice, the East African Legislative Assembly, and the Secretariat. The Inter-University Council for East Africa (IUCEA), operating under the Secretariat, serves as the key institution responsible for harmonizing and strengthening higher education systems across the region.

The IUCEA CS benchmarks [1] were designed by the IUCEA to provide a harmonized structure for BSc CS and BSc IT programs across the EAC partner states. These benchmarks emphasize outcomes-based education and quality assurance integration. The framework provides each program's objectives categorized into academic ability, employability, and personal development. It also provides expected learning outcomes (ELOs) across knowledge, skills (cognitive, practical, interpersonal), and attitude dimensions. The ELO's are program specific and then further devolve into specific course areas. Rather than organizing content into knowledge areas as done in the ACM curriculum [2, 3, 4], the IUCEA benchmarks group courses into three broad categories: core (basic) courses, supporting courses, and specialization courses. Table 1 presents the recommended distribution of courses for the BSc CS program under the IUCEA benchmark framework.

Table 1 : IUCEA BSC Computer Science subject areas

Category	**Description**	
Core	Algorithms and Complexity, Data Structures and Algorithms, Formal Languages and Automata Theory, Architecture and Organization, Electronics, Discrete Structures, Foundations of Logic, Database Management Systems, Relational Databases, Operations Research and Optimization, Principles of Programming	
Support	Foundations	Computer Literacy, Emerging Trends in Computer Science, Physics, Computational Science
	Mathematics	Linear Algebra, Calculus, Probability and Statistics, Numerical Analysis, Complex Analysis, Discrete Structures, Foundations of Logic
	Social & Professional	Social and Professional Issues, Communication Skills, Human Psychology, Research Skills, Innovation and Entrepreneurship, Life Skills

Specialization	Multimedia Systems, Game Programming and Animation, Artificial Intelligence and Knowledge-Based Systems, Parallel, Networking and Distributed Systems, Software Engineering, Mobile Computing, Systems and Information Security

It is also important to note that the IUCEA guidelines require alignment with each partner state's National Qualifications Authority. The intended outcome is that adherence to these benchmarks positions a program for formal accreditation. Consequently, universities that satisfy the IUCEA benchmarks are eligible to apply for IUCEA accreditation.

2.2 ACM/IEEE-CS Computer Science Curricula 2023

The ACM/IEEE-CS CS2023 curricula serves as the global benchmark for CS education. In continuity with earlier frameworks such as CS2008 [3] and CS2013 [4], these curricula guidelines are developed by a Joint Task Force on CS Curricula composed of representatives from the ACM, the IEEE Computer Society (IEEE-CS), and the Association for the Advancement of Artificial Intelligence (AAAI).

The ACM/IEEE-CS CS2023 curricula structures CS education around three overarching competency areas: Software, Systems, and Applications. To support these competencies, the framework defines seventeen Knowledge Areas (KAs). The KA's include Algorithms (AL), Architecture (AR), and Software Engineering (SE), among others. Each KA is further composed of Knowledge Units (KUs), which outline the recommended topics and learning expectations associated with that area. Table 2 presents the organization of the three competency areas and their associated KAs, each of which is composed of specific KUs.

Table 2: IEEE/ACM CS2023 Computer Science Curricula

Knowledge Areas (KA)	**Knowledge Units (KU)**
Competency: Software	
Software Development Fundamentals (SDF)	Fundamentals, Data Structures, Algorithms, Practices, Societal, Ethical and Professional (SEP)
Software Engineering (SE)	Teamwork, Tools, Requirements, Design, Construction, Validation, Refactoring, Reliability, Formal
Foundations of Programming Languages (FPL)	OOP, Functional, Logic, Scripting, Event Driven, Parallel, Aspect, Types, System, Translation, Abstraction, Syntax, Semantics, Analysis, Code, Run-Time, Constructs, Pragmatics, Formalism, Methodologies, Design, SEP
Algorithmic Foundations (AL)	Foundational, Complexity, Strategies, Models, SEP
Competency: Systems	
Architecture and Organization (AR)	Logic, Representation, Assembly, Memory, I/O, Organization, Performance and Energy, Heterogeneity, Security, Quantum,
Operating Systems (OS)	Purpose, Principles, Concurrency, Protection, Processes, Memory, Devices, Files, Virtualization, Faults, Real-time, SEP
Networking and Communication (NC)	Fundamentals (e.g. Internet, transport layers), Applications, Reliability, Routing, SingleHop, Security, Mobility, Emerging
Parallel and Distributed Computing (PDC)	Programs, Communication, Coordination, Evaluation, Algorithms
Systems Fundamentals (SF)	Overview, Foundations (e.g. simple logic gates, finite state machines), Resources, Evaluation, Reliability, Security, Design
Data Management (DM)	Foundations (e.g. Design, Data Life Cycle etc), Modelling, Relational, Querying,

	Processing, No SQL, Analytics (including data mining, visualization), Security, SEP
Security (SEC)	Foundations (e.g. access control, denial of service DoS), SEP, Coding (e.g. input validation), Crypto, Engineering (e.g. security design and engineering), Forensics, Governance
Competency: Applications	
Artificial Intelligence (AI)	Introduction/Foundational (e.g. Agents), Search, Knowledge Representations, Machine learning, SEP
Graphics and Interactive Techniques (GIT)	Fundamentals, Visualization, Rendering, Modelling, Shading, Animation, Simulation, Immersion, Image, Interaction, Physical (e.g. IoT), SEP
Human Computer Interaction (HCI)	User-Centred design, Accountability, Accessibility, Evaluation, Design, SEP
Specialized Platform Development (SPD)	Overview/Common (e.g. Development platforms, Platform Languages), Web, Mobile, Robot, Embedded, Game

In addition to the primary KAs, the CS2023 standards include two cross-cutting KAs: Mathematical and Statistical Foundations (MSF) and Society, Ethics, and the Profession (SEP). These areas provide foundational support across all three competency domains and align closely with the IUCEA benchmark's emphasis on supporting subjects. For example, SEP reinforces the integration of computing ethics, professionalism, and sustainability throughout the curricula.

Moreover, CS2023 expands traditional CS boundaries by integrating emerging areas such as data science, human-centered computing, AI and machine learning, and computing for social good.

3. Methodology

3.1 Selection of Universities

The founding member states of the EAC are Uganda, Kenya and Tanzania. Further, these three countries have the oldest and largest universities in East Africa [13]. Following this, Makerere University (MAK), University of Nairobi (UoN), University of Dar es Salaam (UDSM), and Kenyatta University (KU) were selected for the study. Accredited undergraduate CS programs were considered for this study.

3.2 Set up: IUCEA CS benchmark vs CS2023

To assess the alignment between IUCEA curriculum guidelines and CS2023 knowledge areas, each subject area in IUCEA CS benchmarks was mapped to a particular KA in CS2023 guidelines. Apart from enabling an understanding of how regional curriculum guidelines align with global curriculum guidelines, this mapping also helped to understand how CS curricula in the four studied universities align with regional guidelines, which is important for the comparability of CS graduates across the region

3.3 Set up: EA Universities CS Programs vs CS2023

To assess how CS curricula in each of the four universities align with the CS2023 curriculum guidelines, each course in the respective curricula was mapped to a specific KA in the CS2023. This helped to identify KAs with sufficient and insufficient coverage across the four universities. The number of courses in each knowledge area was used to compute the percentage of representation of that KA in a curriculum.

3.4 Data Sources

Data (in terms of CS courses) was obtained from official university curricula and course syllabi. Where these documents were not available, institutional websites and accreditation documents were used. Further CS2023 Curricula document [2] and IUCEA CS benchmarks [1] were used.

4 Results and Discussion

4.1 IUCEA vs CS2023

Table 3 presents a bidirectional mapping between IUCEA benchmark subject areas and the CS2023 KA. The IUCEA subject areas correspond to the defined core areas (basic CS) and the support and specialization areas. Refer to Table 1 for the distribution. Table 3 shows that there is an overlap between multiple subject areas and mapped KAs, which is to be expected as different subjects might provide a weighing between multiple KAs.

Table 3: A Mapping Between IUCEA Benchmarks and CS2023 CS Curricula Guidelines

CS2023 KA	IUCEA Subject Areas
AL	Algorithms & Complexity, Data Structures & Algorithms, Formal Languages & Automata Theory
AR	Architecture & Organization, Electronics, Physics
MSF	Discrete Structures, Foundations of Logic, Linear Algebra, Calculus, Probability & Statistics, Numerical Analysis, Complex Analysis, Operations Research & Optimization, Computational Science
DM	Database Management Systems, Relational Databases
SDF	Principles of Programming, Computer Literacy
SE	Software Engineering, Research Skills, Innovation & Entrepreneurship
SEC	Systems & Information Security
AI	AI & Knowledge-Based Systems, Computational Science
GIT	Multimedia Systems, Games & Animation
HCI	Human Psychology, Communication Skills, Social & Professional Issues
NC	Parallel, Networking & Distributed Systems (Networking)
PDC	Parallel, Networking & Distributed Systems (Parallel/Distributed), Computational Science
SPD	Mobile Computing
SF	Computer Literacy, Electronics, Physics
SEP	Social & Professional Issues, Communication Skills, Human Psychology, Research Skills, Innovation & Entrepreneurship, Life Skills, Emerging Trends in CS
FPL	Not covered
OS	Not covered

From the mapping in Table 3, it is evident that IUCEA benchmark has some alignment with CS2023 standards. This is particularly seen when looking at the distribution of course coverage across MSF, AL, AR, SEP, DM, and SDF. These courses address core and support areas as defined by IUCEA. For the rest of the courses, there is somewhat a one-to-one mapping between the IUCEA and the KAs. This is because IUCEA provides the specialization as thematic area with a set of courses that would fulfil it. In this respect, the IUCEA specialization can be seen with the same lenses as KA's in the CS2023.

A further analysis shows that there are two missing KAs in the mapping: FPL and OS. Whereas computer literacy could fill in OS, it is not adequate. Similarly, picking Formal Languages and Automata Theory to fill in FPL does not meet the expected rigour and quality in CS. Moreover, some core areas within CS are not well covered under the IUCEA benchmarks. For instance, SDF is only mapped to Computer Literacy and Principles of Programming while HCI's mapping is carried out with only a basic course that would largely fall under SEP. In addition to these, SF is only covered with physics courses with no CS courses listed.

These results highlight an important aspect: reliance on the regional guideline without cross referencing with global standards is not helpful for the EAC universities. Further, for IUCEA to create a credible accreditation for CS with EAC partner states, there is a need to rethink the courses by examining other global accreditors e.g. ABET, British Computer

Society etc, as well as formulating the core areas based on global computing degrees guidelines such as those published by CC2020 [14].

The next section examines how each EAC university curricula aligns with CS2023 and how that reflects on the adherence with IUCEA Benchmarks.

4.2 Knowledge Area coverage among EA Universities

Tables 4 and 5 show the results of each universities coverage of the CS2023 KAs. As outlined in the methodology, each course, within the CS catalogue of each university, was mapped to a primary KA. The authors are aware that one course might overlap multiple KAs and that one KA could be used to create multiple courses. However, the intention of this study was to understand how well each KA was covered. This was done by examining the syllabus for each course, subjecting it to the KAs and their KUs and then building a consensus on which KA was primary for the course. As such, the result entries show the percentage count of courses in a particular university which primarily cover a certain KA.

Table 4: EAC Universities Curricula alignment with CS2023

KA	UoN	KU	UDSM	MAK
SE	11.32%	9.52%	8.70%	14.63%
SDF	9.43%	9.52%	8.70%	7.32%
MSF	7.55%	12.70%	8.70%	9.76%
SEP	16.98%	17.46%	26.09%	19.51%
FPL	3.77%	3.17%	**0.00%**	2.44%
AL	5.66%	6.35%	4.35%	7.32%
AR	7.55%	6.35%	4.35%	2.44%
AI	5.66%	6.35%	4.35%	7.32%
SF	1.89%	1.59%	4.35%	2.44%
DM	5.66%	7.94%	6.52%	4.88%
NC	5.66%	7.94%	10.87%	4.88%
PDC	3.77%	1.59%	**0.00%**	2.44%
SPD	3.77%	**0.00%**	2.17%	2.44%
SEC	3.77%	3.17%	4.35%	4.88%
GIT	3.77%	3.17%	2.17%	2.44%
HCI	1.89%	1.59%	2.17%	2.44%
OS	1.89%	1.59%	2.17%	2.44%
	100.00%	100.00%	100.00%	100.00%

Results shown by Table 4 and Table 5 show a mean coverage of each KA with at least 2 courses. Apart from the lack of coverage of FPL and PDC by UDSM and SPD by KU, generally, all the four universities have a strong Bachelor of CS programs as defined within the CS2023. For instance, core areas within AL, SE, SDF, DM, NC and MSF are very strongly covered. Further, although there was no evidence of SEP integration in each course, though this study did not focus on the specifics of SEP integration in the courses, at the programs level, SEP was the highest covered KA. There are several reasons for this. For UDSM, a lot of materials are drawn from Information Systems (IS domain) which makes courses within that area to be included in the SEP, and for the other universities, there are multiple university common courses, i.e. breadth areas within humanities as well as requirement for field attachment (internship) and research that fulfil these areas. Further, these results show a healthy coverage of MSF with Kenyatta University fulfilling this KA with eight courses.

Table 5: KA coverage among EAC Universities

University	Total Courses	Mean per KA	Std Dev	Max KA	Min KA
UoN	53	3.12	2	9	1
KU	63	3.71	2.84	11	0
UDSM	46	2.71	2.72	12	0
MAK	41	2.41	1.94	8	1

AI is also very well covered. Traditionally, AI is covered at third – fourth year (in a four-year degree) and in second-third year (in a three-year degree). However, it was noted that some universities are teaching AI at first and second years, raising questions on whether student would have enough mathematical and programming background to succeed in an AI course.

There is an increasing connectedness within programming platforms particularly driven by cloud computing, and Internet of Things (IoT). However, results show a very low coverage of SPD. Courses covered under SPD were mobile computing and/or some elective course. This was also seen with PDC where only a course on distributed systems was used to fulfil it. In these areas, Kenyatta University did not have a course covering SPD, and UDSM did not have a course covering PDC.

Connecting these results with the results in Section 4.1, it can be concluded that all the universities exceed the coverage of the IUCEA CS benchmarks and adequately adhere to CS2023 standards. The next section examines whether there is statistically significant difference between each universities CS program based on the KAs.

4.3 CS Programs comparison between EAC Universities

The results in Section 4.2 show that there is a strong coverage of CS2023 KAs among the leading EAC Universities. In this section, results of a Wilcoxon signed-rank test are used to determine whether these CS programs are statistically significantly different when examined under the KAs. Table 6 provides the results for the statistical significance.

Table 6: CS Programs Comparison

University Pair	W Statistic	Z Score	p-value	Significant?
UoN vs KU	12	-1.244	0.2135	ns
UoN vs UDSM	26	-1.02	0.3078	ns
UoN vs MAK	0	-2.666	0.0077	**
KU vs UDSM	7	-2.691	0.0071	**
KU vs MAK	4	-2.578	0.0099	**
UDSM vs MAK	27	-0.533	0.5937	ns

Note that Wilcoxon Signed-Rank was used because the intention was to examine whether the differences between matched KAs are systematically different. Three statistically significant differences were identified: UoN vs. MAK, KU vs. MAK, and KU vs. UDSM. Knowledge Area (KA) analysis was conducted to determine the sources of these differences. For UoN vs. MAK, all differences favored UoN ($W^+ = 45$, $W^- = 0$), with major contributions from AR (+3), SDF (+2), GIT (+1), PDC (+1), and NC (+1). This likely reflects UoN's four-year degree structure, which allows broader coverage compared to Makerere's three-year program. Similarly, KU vs. MAK showed significant differences ($W^+ = 62$, $W^- = 4$), driven by MSF (+4), NC (+3), DM (+3), AR (+3), SEP (+3), and SDF (+3). Makerere's shorter program may limit coverage, while KU benefits from elective cluster offerings not available at the other institutions.

For KU vs. UDSM, differences again favored KU ($W^+ = 84$, $W^- = 7$), with leading contributors including MSF (+4), DM (+2), AI (+2), AR (+2), AL (+2), FPL (+2), SDF (+2), and SE (+2). UDSM allocates a substantial portion of its curriculum to Information Systems (12 of 46 courses) and Information Technology (approximately 5 of 46 courses), making it more IS-oriented with CS/IT electives. This curricular orientation helps explain the observed statistical differences.

5 Conclusions

The work reported in this paper analyzed CS degree programs from four leading EAC universities. The intention was to show adherence with the regional ICUEA Benchmark and to further examine how the CS programs align with IEEE/ACM CS2023. The results show that ICUEA Benchmark needs a new re-examination in the light of changing technological perspectives. Since, the most recent available ICUEA guidelines is of 2015, it is recommended that the designers for this regional framework rework this with lenses of both CC2020 and CS2023. Further, since ICUEA seeks to also accredit programs within the region, then benchmarking their accreditation criterion based on global standards such as ABET and British Computer Societies will help lead to a successful program. Despite the ICUEA vs CS2023 divergence, CS programs offered by the leading universities have a very strong coverage of the KA that comprise CS2023. As such, these CS programs are aligned and exceed the expectation of the ICUEA. Consequently, they can help the designers of the ICUEA benchmarks in coming up with future benchmarks.

When the CS programs are compared in the light of the coverage of the KAs, pairwise statistically significant differences are observed between UoN vs MAK, KU vs MAK, and KU vs UDSM. The results and the ensuing discussion show that the program focus, and lengths are determining factor to these differences. It is also important to note the temporal differences among the analyzed frameworks and curricula. While CS2023 was published in 2024, the IUCEA benchmarks date to 2015, and some university curricula predate the latest ACM guidelines. As institutions revise their programs, future assessments may reveal evolving alignment trends. Additionally, future work will examine cases where courses fulfill multiple Knowledge Areas and expand the analysis to include newer universities across the region.

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Declaration of use of content generated by Artificial Intelligence (AI) (including but not limited to Generative-AI) in the paper

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