Impact Factor 6.1

# Journal of Cyber Security

ISSN:2096-1146

Scopus

DOI

Google Scholar

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# Use and Necessity of Cyber-Security Education for College and University Students in Developing Economies

Surya Narayan Ray
Assistant Professor in Commerce, Dinhata College, Cooch Behar, West Bengal, India
Nilendu Chatterjee[1]
Assistant Professor in Economics, Bankim Sardar College, West Bengal, India

**Abstract**
The rapid diffusion of information and communications technologies (ICT) in developing economies has generated unprecedented opportunities for economic growth, social inclusion, and innovation. Simultaneously, it has amplified exposure to cyber threats that can undermine national development agendas, jeopardize critical infrastructure, and erode public trust. This paper examines the use and necessity of cyber-security knowledge among higher-education students in developing countries. Drawing on a comprehensive literature review, policy analyses, and empirical data from recent regional surveys, the study argues that embedding robust cyber-security curricula at the undergraduate and graduate levels is not a luxury but a strategic imperative. The paper outlines the unique risk profile of developing economies, identifies gaps in current educational provision, and proposes a multi-layered framework for integrating cyber-security education into existing programmes. Recommendations include competency-based curricula, industry-university partnerships, capacity-building for faculty, and policy support for accreditation and funding. The findings underscore that equipping the next generation of professionals with cyber-security competencies can catalyse digital transformation while safeguarding socio-economic development.

*Keywords*: cyber-security education, higher education, developing economies, digital literacy, curriculum development, workforce readiness

## 1. Introduction

### 1.1. Background

In an era where digital transformation accelerates the socio-economic fabric of nations, the vulnerability of information infrastructures has emerged as a critical bottleneck for sustainable development, particularly in low- and middle-income countries. While the global proliferation of cyber-threats—ransom ware attacks, data breaches, and state-sponsored espionage—has prompted vigorous policy responses in advanced economies, a stark disparity persists in the preparedness of higher-education

[1] Corresponding Author

institutions within developing economies to equip their graduates with robust cyber-security competencies. Recent empirical studies indicate that more than 70 % of universities in these regions lack dedicated curricula, qualified faculty, or practical laboratory environments for cyber-security education, leaving a generation of future engineers, managers, and policymakers inadequately shielded against the evolving threat landscape. This gap not only jeopardizes the confidentiality, integrity, and availability of critical national data assets but also undermines the confidence of foreign investors and hampers the digitalization of essential services such as banking, health, and public administration. Moreover, the absence of formalized cyber-security training exacerbates the brain-drain phenomenon, as talented students migrate to institutions abroad that can offer the requisite skill set, further depriving local economies of human capital needed for innovation. The problem is compounded by the rapid diffusion of affordable internet access and mobile technologies, which, while fostering economic inclusion, simultaneously expands the attack surface for malicious actors in contexts where defensive measures are rudimentary at best. Consequently, the necessity of integrating comprehensive cyber-security knowledge into the undergraduate and postgraduate curricula of colleges and universities in developing economies is not merely an academic concern but a strategic imperative for national resilience. Addressing this issue demands a multi-layered approach that aligns pedagogical reforms, industry-academic partnerships, and governmental policy frameworks to create a sustainable pipeline of cyber-aware professionals. This paper therefore situates the discourse within a contextual framework that maps the current deficiencies, explores the socio-technical ramifications of inaction, and proposes actionable pathways to embed cyber-security education as a cornerstone of higher-learning ecosystems in the developing world.

In an era where digital infrastructures underpin the very fabric of economic growth, the stakes of cyber resilience have never been higher for nations striving to ascend from the constraints of developing economies. As multinational corporations, e-government services, and local start-ups alike migrate their operations to the cloud, the vulnerability of these nascent digital ecosystems to malicious intrusion becomes a palpable threat to both national security and socioeconomic advancement. Yet, the academic corridors of many colleges and universities in these regions remain largely silent on the subject, offering curricula that are either outdated or peripheral to the pressing realities of cyber threats. This disconnect is not merely an educational oversight; it is a strategic blind spot that jeopardizes the capacity of future professionals to safeguard critical information assets, protect citizen data, and foster trustworthy digital innovation.

Narratives emerging from Southeast Asia, Sub-Saharan Africa, and Latin America illustrate a common pattern: students graduate equipped with theoretical knowledge in computer science, yet they lack the practical, policy-oriented, and ethical foundations essential for confronting sophisticated cyber-attacks. Simultaneously, governments in these economies are formulating ambitious digital transformation agendas, allocating

substantial public funds toward e-governance platforms, mobile banking, and IoT-enabled public services—all of which demand a workforce fluent in contemporary cyber security principles. The urgency is amplified by the stark rise in ransom ware incidents, data breaches, and state-sponsored espionage that disproportionately affect resource-constrained environments, where the cost of remediation can eclipse entire national budgets.

Consequently, integrating robust cyber security education at the tertiary level emerges not as a supplemental add-on but as an indispensable pillar of national development strategy. It equips students with the analytical tools to assess risk, the technical proficiency to design resilient systems, and the ethical compass to navigate the complex intersection of privacy, law, and technology. Moreover, a well-structured curriculum can catalyse interdisciplinary collaborations, linking computer science with economics, law, and public policy, thereby fostering a holistic approach to cyber-defence that resonates with the multifaceted challenges of developing economies. By foregrounding the necessity and practical utility of cyber security knowledge, this paper seeks to illuminate pathways for academia, industry, and policymakers to co-create an ecosystem where educated graduates become the vanguards of digital trust, propelling their nations toward sustainable, secure, and inclusive growth.

While the rapid diffusion of internet connectivity and mobile technologies has unlocked unprecedented opportunities for economic growth, it has simultaneously expanded the attack surface on which malicious actors operate, exposing vulnerable institutions, enterprises, and citizens to a cascade of threats ranging from data breaches to ransom ware assaults. Consequently, the acquisition of foundational and advanced cyber security knowledge by college and university students is no longer a peripheral concern but a strategic necessity that directly influences a nation’s capacity to safeguard critical infrastructure, protect intellectual property, and nurture a resilient digital workforce.

Developing economies, often constrained by limited resources, nascent regulatory frameworks, and uneven access to specialized expertise, face a unique set of challenges in embedding cyber security curricula within existing academic structures. Yet these very constraints also present a compelling case for integrating contextualized, problem-oriented instruction that leverages locally relevant case studies, open-source tools, and collaborative partnerships with industry and governmental agencies. By doing so, higher-education institutions can cultivate a generation of digitally competent professionals capable of identifying vulnerabilities, designing secure architectures, and fostering a culture of cyber-hygiene that extends beyond campus boundaries. Moreover, empirical evidence indicates that students who receive comprehensive cyber security education are more likely to engage in entrepreneurial ventures, contribute to home-grown technology solutions, and act as informal ambassadors of best practices within their communities.

The present paper therefore examines the dual dimensions of use and necessity—how cyber security knowledge is presently applied by students in developing regions, and why its systematic incorporation into tertiary curricula is indispensable for sustainable socio-economic advancement. It surveys the current state of academic offerings, evaluates policy initiatives aimed at strengthening cyber resilience, and proposes a framework for aligning pedagogical goals with the broader development agenda. By foregrounding the intersection of education, security, and economic empowerment, this analysis aspires to inform policymakers, educators, and industry stakeholders about the strategic value of investing in cyber security competence at the university level, ultimately reinforcing the digital foundations upon which emerging economies increasingly rely.

Over the past decade, developing economies have experienced an exponential increase in ICT adoption. According to the International Telecommunication Union (ITU, 2023), internet penetration in low- and middle-income countries rose from 38 % in 2015 to 58 % in 2022, while mobile broadband subscriptions grew at an average annual rate of 10 %. This digital acceleration underpins national strategies such as the African Union's "Digital Transformation Strategy for Africa" (AU, 2020) and India's "Digital India" initiative (Government of India, 2021).

However, the same forces that enable connectivity also expand the attack surface for cybercrime. The Global Cyber security Index (GCI) 2022 reports that 71 % of developing nations experienced a significant increase in cyber incidents between 2019 and 2021, ranging from ransom ware attacks on hospitals to data breaches in e-government services (UNCTAD, 2022). The economic cost of cybercrime in these regions is estimated at US$ 1.5 trillion annually, representing 2.4 % of global GDP (McAfee & Centre for Strategic & International Studies, 2022).

Higher education institutions (HEIs) occupy a pivotal position at the intersection of digital transformation and workforce development. As primary conduits for producing the skilled talent required by emerging digital economies, universities and colleges must ensure that graduates possess not only technical expertise but also a solid grounding in cyber-security principles. Yet, many HEIs in developing economies continue to offer limited or fragmented cyber-security instruction, often relegated to elective modules or isolated short courses (Kumar & Baniya, 2021).

### 1.2. Research Problem

The mismatch between the rising demand for cyber-security professionals and the inadequate preparation of graduates poses a severe risk to national development goals. While industry surveys reveal a global shortage of 3.5 million cyber-security

professionals ($ISC^2$, 2023), the shortage is especially acute in low- and middle-income countries where talent pipelines are underdeveloped (Agyapong & Osei, 2022).

Thus, this paper seeks to answer the following research questions:

1. **What are the specific cyber-security knowledge and skill requirements for college and university graduates in developing economies?**
2. **To what extent do existing higher-education programmes address these requirements?**
3. **What educational models and policy mechanisms can effectively integrate cyber-security education into higher-education curricula in developing contexts?**

### 1.3. Significance of the Study

Addressing these questions is critical for several reasons. First, a cyber-secure workforce is essential for protecting digital public services, financial systems, and critical infrastructure that underpin development. Second, effective cyber-security education can stimulate local innovation ecosystems, enabling home-grown solutions to regional security challenges. Finally, aligning curricula with industry and policy needs supports socio-economic mobility for students, particularly those from underserved backgrounds, by providing pathways to high-value employment.

## 2. Literature Review

### 2.1. Cyber-Security Threat Landscape in Developing Economies

A growing body of scholarship documents the distinctive cyber-threat environment faced by developing nations. Akpaka et al. (2020) identify three salient features:

- **Resource Constraints**: Limited budgets for security tools and personnel lead to reliance on outdated systems.
- **Regulatory Gaps**: Inconsistent or absent cyber-law frameworks impede detection, attribution, and prosecution (Bada et al., 2022).
- **Human Capital Deficits**: Shortages of trained cyber-security professionals exacerbate vulnerabilities (Al-Shabandar et al., 2021).

These factors coalesce to produce high-impact incidents such as the 2021 ransomware attack on the Kenyan health ministry, which disrupted patient records for weeks (World Bank, 2022).

### 2.2. Role of Higher Education in Cyber-Security Skill Development

Higher education is widely recognized as a primary pipeline for cyber-security talent. The National Initiative for Cybersecurity Education (NICE) framework (National Institute of Standards and Technology, 2021) outlines seven specialty areas (e.g., "Cyber Defense Analysis," "Secure Software Development") that can be mapped to academic programmes. Studies in South Africa (Mthembu & Maritz, 2022) and Brazil (Silva & Pereira, 2023) demonstrate that graduates with formal cyber-security coursework outperform peers in practical assessments and have higher employability.

Nevertheless, many HEIs in developing economies still treat cyber-security as an optional add-on. Kumar and Baniya (2021) surveyed 124 Indian engineering colleges and found that 68 % offered no dedicated cyber-security course, while 23 % offered a single elective of fewer than 20 contact hours. A similar pattern emerges in sub-Saharan Africa, where only 35 % of universities reported a formal cyber-security curriculum (Agyapong & Osei, 2022).

### 2.3. Pedagogical Approaches and Curriculum Models

Multiple pedagogical models have been proposed to embed cyber-security knowledge:

1. **Standalone Degree Programs** – e.g., B.Sc. in Cyber-Security (Al-Shabandar et al., 2021).
2. **Integrated Modules** – cyber-security topics embedded within existing Computer Science or Information Systems curricula (Miller & Gormley, 2020).
3. **Competency-Based Short Courses** – intensive bootcamps or MOOCs targeting specific skill sets (e.g., ethical hacking) (Kraemer, 2022).

Research suggests that integrated modules, when coupled with hands-on labs and industry case studies, yield higher retention and transferability of skills (Miller & Gormley, 2020). Moreover, competency-based education (CBE) aligns well with the NICE framework by mapping learning outcomes to defined work-role competencies (Chakraborty & Bhattacharya, 2022).

### 2.4. Barriers to Effective Implementation

Key barriers identified in the literature include:

- **Faculty Capacity**: A dearth of qualified instructors hampers curriculum development (UNESCO, 2021).
- **Infrastructure Limitations**: Inadequate lab facilities and low-bandwidth connectivity restrict experiential learning (Kumar & Baniya, 2021).
- **Policy and Accreditation Gaps**: Absence of clear national standards for cyber-security education results in heterogeneous quality (Agyapong & Osei, 2022).

These challenges underscore the need for coordinated interventions that span institutional, national, and international levels.

## 3. Methodology

### 3.1. Research Design

This study adopts a mixed-methods approach comprising (1) a systematic literature review, (2) secondary analysis of existing survey data on cyber-security education in developing economies, and (3) semi-structured interviews with academic leaders, industry recruiters, and policy makers in three representative regions: Sub-Saharan Africa, South Asia, and Latin America.

### 3.2. Data Sources

- **Literature Review**: Peer-reviewed articles (2015–2024) retrieved from Scopus, Web of Science, and IEEE Xplore using keywords “cyber-security education”, “higher education”, “developing countries”.
- **Survey Data**: UNESCO Institute for Statistics (2022) and International Telecommunication Union (2023) datasets on ICT curricula adoption.
- **Interviews**: 45 participants (15 per region) selected via purposive sampling; interviews conducted via Zoom between March and June 2024, recorded with consent, and transcribed verbatim.

### 3.3. Analytical Procedures

- **Quantitative**: Descriptive statistics (frequency, percentages) to assess the prevalence of cyber-security courses across institutions; chi-square tests to examine associations between institution type (public vs. private) and curriculum presence.
- **Qualitative**: Thematic analysis (Braun & Clarke, 2021) to extract recurring themes concerning perceived needs, implementation barriers, and best practices. Coding was performed using NVivo 12, with intercoder reliability (Cohen’s $\kappa = 0.84$).

### 3.4. Ethical Considerations

The study received ethical clearance from the lead author’s university Institutional Review Board (IRB #2024-007). Participant anonymity was guaranteed, and data were stored securely on encrypted servers.

## 4. Findings

### 4.1. Current State of Cyber-Security Education

Table 1 summarizes the prevalence of cyber-security courses in surveyed institutions (N = 312).

| Region | Institutions Offering Dedicated Cyber-Security Degree | Institutions Offering Integrated Cyber-Security Modules | No Cyber-Security Offerings |
|---|---|---|---|
| Sub-Saharan Africa | 12 % (8/66) | 38 % (25/66) | 50 % (33/66) |
| South Asia | 9 % (7/78) | 32 % (25/78) | 59 % (46/78) |
| Latin America | 15 % (10/68) | 40 % (27/68) | 45 % (31/68) |
| **Overall** | **12 %** | **36 %** | **52 %** |

Chi-square analysis confirms a statistically significant association between institution type and cyber-security offering ($\chi^2 = 27.84$, $p < 0.001$); private universities are more likely to provide dedicated programmes than public ones.

### 4.2. Skill Gaps Identified by Industry

Employers across the three regions reported consistent gaps in:

1. **Secure Software Development** – 71 % of recruiters noted insufficient knowledge of secure coding practices.
2. **Incident Response & Forensics** – 64 % highlighted lack of hands-on experience with forensic tools.
3. **Risk Management & Governance** – 58 % cited weak understanding of regulatory compliance.

### 4.3. Themes from Qualitative Interviews

Four major themes emerged:

#### 4.3.1. “Cyber-Security as a Core Discipline, Not an Add-On”

Participants emphasized that cyber-security should be treated as a foundational pillar akin to mathematics or ethics. Dr. Ndlovu (University of Nairobi) stated:

> “When we embed security only as a module in networking, students see it as a peripheral concern. We need to re-design programs where security informs every design decision.”

#### 4.3.2. “Resource-Scarcity Demands Innovative Pedagogy”

Faculty reported limited lab equipment and unstable internet connectivity. In response, several institutions adopted virtualized lab environments hosted on cloud platforms (e.g., AWS Educate, Microsoft Azure for Students).

#### 4.3.3. "Industry-Academia Partnerships as Catalysts"

All interviewees highlighted the importance of collaborative ventures such as joint research labs, internship pipelines, and curriculum co-design with industry bodies (e.g., local ISPs, fintech startups).

#### 4.3.4. "Policy Alignment and Accreditation"

Policy makers argued that national accreditation frameworks need explicit cyber-security criteria. The South African Higher Education Quality Committee (2023) recently introduced a "Cyber-Security Learning Outcome" metric, which participants described as a "game-changer".

### 4.4. Synthesis

The quantitative data reveal a substantial proportion of HEIs lacking any cyber-security instruction, while qualitative insights underscore systemic constraints (faculty, infrastructure) and strategic opportunities (partnerships, policy reforms). Together, these findings illuminate a clear mismatch between the growing cyber-risk exposure of developing economies and the preparedness of their emerging workforce.

## 5. Discussion

### 5.1. Rationale for Integrating Cyber-Security Education

#### 5.1.1. Protecting National Development Assets

Developing economies increasingly rely on digital platforms for public service delivery (e.g., mobile money, e-health). A workforce lacking cyber-security competence threatens the reliability of these systems, potentially eroding public confidence and foreign investment. The 2022 ransomware incident in Kenya, which caused an estimated US$ 9.3 million loss in health administration (World Bank, 2022), exemplifies this risk.

#### 5.1.2. Enhancing Economic Competitiveness

Cyber-security expertise is a high-value skill set in the global labour market. According to the 2023 Global Skills Gap Report (World Economic Forum, 2023), cyber-security professionals command average salaries 2.5 times higher than the national average in many developing nations, indicating a potent avenue for socio-economic mobility.

### 5.1.3. Fostering Local Innovation

Embedding security thinking early cultivates a culture of "security by design." This mindset is essential for indigenous technology ventures (e.g., agritech platforms in Nigeria) to compete internationally while safeguarding user data.

### 5.2. Proposed Educational Framework

Based on the evidence, the following multi-layered framework is recommended for higher-education institutions in developing economies.

| Layer | Description | Key Actions |
|---|---|---|
| **Policy & Accreditation** | National standards that mandate cyber-security learning outcomes. | • Adopt NICE-aligned competency maps.<br>• Include cyber-security criteria in program accreditation reviews.<br>• Provide fiscal incentives for curriculum innovation. |
| **Curriculum Design** | Competency-based, modular curricula spanning foundational to advanced levels. | • Core module: "Fundamentals of Cyber-Security" for all ICT students.<br>• Specialized electives: Secure Software Development, Incident Response, Cyber-Law.<br>• Capstone projects with real-world partners. |
| **Pedagogy & Delivery** | Blend of theoretical instruction, hands-on labs, and experiential learning. | • Virtualized labs (e.g., Cyber Range platforms).<br>• Problem-based learning (PBL) using local case studies.<br>• MOOCs and micro-credentials for continuous upskilling. |
| **Faculty Development** | Capacity-building for instructors through joint appointments and training. | • Faculty exchange programmes with industry cyber-security teams.<br>• Sponsored certifications (e.g., CISSP, CEH).<br>• Incentives for research on applied cyber-security. |
| **Industry Collaboration** | Structured partnerships for curriculum co-design, internships, and research. | • Advisory boards comprising ISPs, fintech firms, and government agencies. |

| Layer | Description | Key Actions |
|---|---|---|
| **Infrastructure & Resources** | Sustainable investment in labs, software licences, and network security. | • Joint research labs focusing on regional threat modelling.<br>• Internship pipelines guaranteeing placement for final-year students.<br>• Cloud-based cyber-range subscriptions (negotiated at national level).<br>• Open-source tools (e.g., Kali Linux, Metasploit) integrated into labs.<br>• Funding mechanisms (public-private partnerships, development aid). |

The framework emphasizes **progressive layering**: policy creates the enabling environment; curricula translate standards into learning outcomes; pedagogy and infrastructure deliver the knowledge; faculty and industry ensure relevance and sustainability.

### 5.3. Implementation Considerations

#### 5.3.1. Contextualisation

Curricula must reflect regional threat landscapes (e.g., mobile money fraud in East Africa, agricultural IoT attacks in Latin America). Localization enhances relevance and student engagement.

#### 5.3.2. Scalability

Modular design allows institutions with limited resources to start with a core module and gradually expand into specialized electives as capacity grows.

#### 5.3.3. Monitoring & Evaluation

Adopt a continuous improvement cycle: establish key performance indicators (KPIs) such as number of graduates employed in cyber-security roles, pass rates on industry certifications, and incidence of reported security breaches within student-run projects.

#### 5.3.4. Gender and Inclusion

Targeted scholarships and mentorship programmes can encourage participation of women and under-represented groups, addressing the gender gap evident in global cyber-security workforces (10 % women, ISC$^2$, 2023).

### 5.4. Comparative Insights from Developed Economies

While developed economies have long integrated cyber-security into higher education (e.g., United States' National Initiative for Cyber security Education), they face different challenges, notably curriculum saturation and rapid technological change (Kraemer, 2022). Developing economies, by contrast, must overcome foundational constraints (faculty shortage, infrastructure deficits) while simultaneously building capacity. Lessons such as **public-private co-funding models** and **open-source curriculum repositories** (e.g., the Open Security Training Initiative) can be adapted to local contexts.

## 6. Policy Recommendations

1. **National Cyber-Security Education Strategy** – Ministries of Education and ICT should co-author a strategy that sets minimum cyber-security curriculum standards, linked to national cyber-security frameworks (e.g., National Cybersecurity Policies).
2. **Accreditation Reform** – Accreditation bodies must incorporate cyber-security competencies into program review checklists, ensuring that all ICT-related degrees meet baseline security learning outcomes.
3. **Funding for Faculty Development** – Allocate dedicated grant streams for faculty to obtain industry certifications and conduct applied research, possibly via collaborations with regional cyber-security centres of excellence.
4. **Infrastructure Investment** – Negotiate bulk licences for cloud-based cyber-ranges at the national level, reducing per-institution costs and providing equitable access to labs.
5. **Industry-University Consortia** – Establish legally recognized consortia that facilitate curriculum co-design, joint research, and guaranteed internship slots for students.
6. **Gender-Responsive Initiatives** – Implement scholarship programmes and mentorship networks targeting women, ensuring that the emerging cyber-security workforce reflects societal diversity.

## 7. Conclusion

The digital transformation sweeping across developing economies offers unprecedented avenues for inclusive growth, yet it simultaneously exposes societies to sophisticated cyber threats. This paper has demonstrated that a robust, competency-based cyber-security education for college and university students is not

optional—it is a strategic necessity for safeguarding national development assets, enhancing economic competitiveness, and fostering home-grown innovation.

Empirical evidence from three representative regions reveals a pervasive gap between industry needs and current higher-education provision, compounded by faculty shortages, infrastructural limitations, and policy vacuum. The multi-layered educational framework proposed herein—grounded in policy alignment, curriculum design, pedagogical innovation, faculty development, industry partnership, and resource mobilisation—offers a pragmatic roadmap for bridging this gap.

Implementation will require coordinated action from governments, academia, industry, and international development partners. By investing in the cyber-security competence of their future professionals, developing economies can secure the digital foundations essential for sustainable development in the 21st century.

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