IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

Computing Disciplines Competency Framework for the Digital Age

Bostley Muyembe Asenahabi

School of Science, Technology and Engineering, Alupe University, Kenya

Abstract: The field of computing has rapidly evolved from the 1960s into distinct disciplines: Computer Science, Computer Engineering, Information Technology, Information Systems, Software Engineering, and more recently, Information and Communication Technology. While this diversity enriches the profession, it has also created a problem. The overlapping competencies and blurred boundaries make it difficult for: learners to choose appropriate pathways, trainers to impart discipline-specific skills, and employers to interpret graduate profiles. This leads to mismatched expectations, skill gaps and inefficiencies in the workforce thus weakening the ability of computing education to meet organizational and societal demands. This study clarifies the uniqueness of each computing discipline, highlighting their philosophies, competencies, and graduate profiles. The study employed a desktop research method, drawing on secondary data from academic publications, professional guidelines, and industry reports. Sources were selected based on credibility, relevance, and recognition by established bodies. The analysis involved systematically reviewing literature to identify recurring themes, disciplinary distinctions, and competency frameworks. Sources were cross-checked for authenticity, with preference given to peer-reviewed works and publications indexed in reputable databases. Findings were synthesized by comparing perspectives across disciplines, highlighting overlaps, and distinguishing unique competencies. This triangulated approach ensured that conclusions were both academically robust and practically relevant. By distinguishing these pathways, the study ensures that learners acquire targeted skills aligned with career aspirations, trainers deliver curricula that reflect discipline-specific competencies, and employers can interpret graduate profiles accurately to reduce skill mismatches. Ultimately, society benefits from graduates whose competencies are tailored to solving real-world problems through computing technologies. This study contributes to bridging the gap between education and practice by offering clarity on computing disciplines. It empowers learners to make informed choices, trainers to design effective programs, employers to align talent with organizational needs, and policymakers to strengthen curricula that support national and global development. In doing so, the paper positions computing education as a driver of innovation, efficiency, and societal progress.

Keywords: computing disciplines, computing curriculum pathways, unique competencies, graduate profiles, digital transformation, ICT

I. INTRODUCTION

Computer literacy has become indispensable for today's workforce, offering a cutting edge in an increasingly computerized environment. Individuals and organizations alike now seek computing skills to remain competitive, yet the uniqueness of computing disciplines remains a dilemma for many learners, trainers, and employers. This lack of clarity often complicates choices about which discipline to pursue and which competencies are most relevant for organizational needs.

The ongoing technology revolution has transformed computing from simple information capture and storage into a driver of innovation across nearly every sector [1]. As computing devices evolved, so too did the disciplines themselves, each developing distinct philosophies and competencies. The Association for Computing Machinery (ACM) formally recognized five core disciplines: Computer Science, Computer Engineering, Information Technology, Information Systems, and Software Engineering while Information and Communication Technology (ICT) has emerged as an amalgamation of these fields [2].

The overlap among these disciplines has created confusion for stakeholders: Learners struggle to choose pathways that align with their career goals; trainers face difficulty in imparting discipline-specific skills while employers often misinterpret graduate profiles. This leads to mismatched expectations, skill gaps, and inefficiencies in the workforce. Organizations may hire graduates whose competencies do not fully meet their operational needs, while learners risk investing in training that does not prepare them for the roles they aspire to. Computing is foundational to modern society, and unclear distinctions weaken the ability of education systems to produce graduates who can drive innovation and meet societal demands.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

This study therefore seeks to highlight the uniqueness of each computing discipline, ensuring that graduates acquire competencies tailored to solving real-world problems and advancing organizational and societal goals.

II. COMPUTING DISCIPLINES EVOLUTION

True to Fein's prediction about some computing-related fields coalescing and developing into disciplines of their own [3], the Association for Computing and Machinery (ACM) recognized five computing disciplines: Computer Science, Computer Engineering, Information Technology, Information Systems, and Software Engineering [2] and an additional discipline, Information and Communication Technology has emerged, as an amalgamation of the five disciplines.

In the 1960s, the impact made by the computer began to curve its niche and this made the academia to recognize it as a discipline and educate students about it. Two distinct computing disciplines: computer science and information systems arose to address this requirement [4]. Electrical engineering was a closely related field that facilitated and supported their operations [5]. During this era, few people in Kenya clearly understood what computing was as it was for the very few who had the privilege to learn some programming in mathematics related programmes [6].

Computer science programs coiled out of mathematics and engineering programs. It emphasized on the programming of computers, development of algorithms, theory of computing, and closely related topics. Information Systems was handled as a business discipline with special attention on programs in accounting. It emphasized on the application of computers in the accounting field with special ettention on information system design, systems operation and maintenance, information system management and accounting programs [4].

In the 1970s, if one had to take some computer related courses in Kenya, he had to be equiped with good analytical and mathematical skills [6]. Great emphasis on teaching computer related courses was pegged on programming.
Two computing related disciplines emerged in the late 1980s: computer engineering and software engineering. Computer engineering emerged out of an amalgametion of electrical engineering and computer science. Electrical engineering graduates with knowledge in digital circuits and logic design offered their skills to computer hardware organizations like IBM and Intel and out of that, together with the realization that the computer hardware required programming at machine level and the developments in the electronic field led to the rise of computer engineering as an independent field. The need for exhaustive methods of developing software which was driven by the creation of complex programs led to the rise of software engineering [6]; [4].

In the 1990s, the emergence of world wide web led to the explosive growth in using the internet which led to the rise of information technology, a discipline which rapidly grew because of the rate of expansion of the field of networked computing [4]. During the same period, different people across the world had formed opinions on computing with those who were for it pointing out that computing was a legitimate discipline with its own identity while some dismised it as a pseudo-discipline for computer programmers, a research area for mathematicians and a vocational specialty for technicians with its own developed considerable body of research, knowledge, and innovation that spanned the range from theory to practice [4]. The controversy surrounding its legitimacy soon withered away. During this time, computing became recognized as an indipendent discipline in Kenya with computer science, information systems and computer engineering being adopted as distinct fields of study. Computer science begun being established as a department in Kenyan institutions of higher learning [6] with the demand for computer science graduates exceeding the supply. People who had any knowledge of computing were quickly absorbed by industries regardless of whether the skills they possesed were the ones required by the industry leading to most of them learning the required skills on-job.
The capability of networked computers came along with a new challenge to the Kenya computing stakeholders in the late 1990s. The adoption of computers in performing diversified activities led to computers generating a lot of information and organizational processes were enriched by computing technology [5]. Challenges of information management and effective use of the information and technology to uplift organization standards led to the adoption if information systems and information technology as well defined disciplines, something that had already been accepted in different parts of the world [6].

In the 2010s, a distinct computing discipline termed as information communication technology emerged which formed an amalgamation of the three thematic families that were present in the 1990s. It is developing its own philosophy majory basing on philosophy of information, communication and technology.

It encapsulates all evolving and emerging technologies around computer hardware and software, telecommunications, networking, programming and internet. ICT arises out of information technology which is concerned with the computer process of storing, retrieving and manipulation of data when both computer hardware and software are included and

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026
DOI: 10.17148/IJARCCE.2026.15901

communication technology which is concerned with how computers and computer related devices communicate with each other remotely [6]. The evolution of computing disciplines as discussed above is graphically captured in Figure 1.

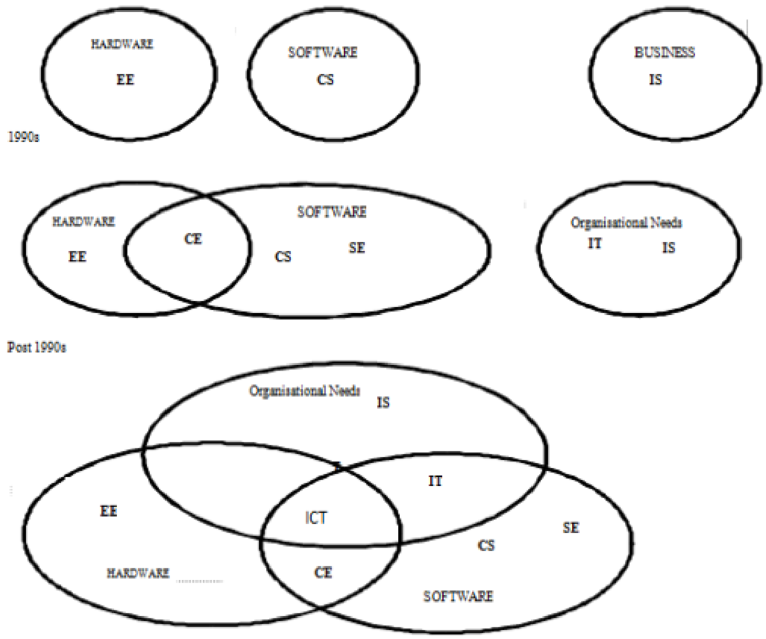

Figure 1: Computing discipline evolution as at 2018. Adopted from [6]- Stakeholders' dilemma and academic leadership on the different computing disciplines

III. UNIQUENESS OF COMPUTING DISCIPLINES

Computing disciplines have a lot in common. However, their uniqueness and philosophies has been used to group them into different categories.

A. Computer Science

Computer Science covers a wide area, from its theoretical computation, complexity analysis and algorithm foundation to exciting developments in artificial intelligence, robotics, computer vision, intelligent systems, and bioinformatics [7] which serve as the backbone for all modern computing systems. It is deeply rooted in mathematics, logic, and engineering principles. It deals with the technical working of computers. As [2] and [8] observe, computer scientists are fundamentally trained to discover optimal solutions for emerging challenges, generate new technologies, and develop innovative approaches that extend the boundaries of computing capability.

Computer scientists work fall in three categories: developing effective ways to solve computing problems; designing new ways to use computers; designing novel applications of computing technology and implementing robust software systems. This tripartite framework requires graduates to demonstrate proficiency not only in technical implementation but also in problem formulation, algorithmic thinking, and systematic evaluation of computational solutions. They are trained to discover the best solutions for new problems like sending data over networks, generate new technologies and come up with innovative ideas like coming up with robots which demonstrate intelligence to do practical work, to use database in the best way possible to create new knowledge and to use computers to help decipher the secrets of our DNA. They design and test software that applies theory to practice and creating innovations with new approaches in mind [8].

From this perspective, computer scientists deal with research work that involves the technical working of computers. They focus on generating and extending computer technology including applications which is applied by other professionals like Information technology professionals to solve real-world problems effectively. The field of Computer Science can be closely linked to electrical engineering, mathematics and logic [9]. Basically, computer science offers comprehensive foundation that permits graduates to adapt to new technologies and new ideas. Strong emphasis is placed on designing and generating programs based on programming languages, software architecture, data structures and algorithms. Computer science students require a great foundation in physics and mathematics so that they can be able to comfortably extend the underlying computer technology. The curriculum must therefore balance theoretical depth with practical application, ensuring graduates possess both conceptual understanding and implementation capability.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

Computer science graduates require several unique competencies which set them apart from other graduates. The competencies are organized into five interconnected domains: programming and software development, algorithms and data structures, computer architecture and systems, data management and databases, and artificial intelligence and machine learning.

Computer science graduates need strong skills in designing, building, and testing software [8], including different programming styles like object-oriented, procedural and functional approaches. They must also design software architectures for complex systems, balancing performance, security, and maintainability. [10] confirm that employers want graduates who can write clean, efficient, maintainable code which makes solid programming skills essential for career success in computing.

Software testing, debugging, and quality assurance are key programming skills, covering unit, integration, system, and acceptance testing, plus test-driven development and automated testing. Project-based, collaborative learning strengthens these skills [11]. Graduates should also understand both waterfall and agile development methods, version control, documentation, and teamwork practices like code reviews and pair programming. These skills combine technical ability with professional collaboration.

Computer scientists are defined by solving computing problems effectively [2] which requires knowledge of algorithms for searching, sorting, and optimization. Designing novel algorithms using approaches like divide-and-conquer, dynamic programming, and greedy methods is a higher-order skill, along with formulating problems and proving correctness. Algorithmic thinking distinguishes computer science graduates, enabling systematic problem-solving [12].
Understanding data structures like arrays, linked lists, stacks, queues, trees, graphs, and hash tables is essential, including knowing when to use each based on performance needs. [13] found that choosing appropriate data structures strongly predicts professional success, requiring awareness of trade-offs affecting memory usage, cache behavior, and parallel processing performance.

Computer Science is rooted in engineering principles covering how computers work technically [9]. Graduates must understand computer organization to reason about how software runs on hardware, including concepts like pipelining and caching. Understanding the hardware-software interface, including assembly language and system-level programming, helps graduates design efficient systems, especially where performance matters [14].

Understanding operating systems is essential, along with concurrency, synchronization, and deadlock prevention for building reliable multi-threaded applications. Knowledge of virtualization and containerization matters as cloud computing grows. Graduates also need network and distributed systems skills, including protocols and challenges like consistency and availability, reflecting the industry's shift toward cloud-native applications [15].

Computer scientists must acquire skills to manipulate databases effectively to create new knowledge [2]. This requires skills in relational and NoSQL database design, entity-relationship modeling, normalization, SQL, and query optimization. Database competency is essential given the rise of data-intensive applications [16] and the growing need to manage and extract value from data [17]. Advanced skills include big data technologies like distributed file systems, MapReduce, stream processing and NoSQL systems like document and graph databases. Data warehousing, and data quality management round out these competencies, supporting analytical querying as organizations increasingly rely on data-driven decision making.

Computer Science underpins AI, robotics, and intelligent systems [7]. Graduates must understand machine learning approaches like supervised, unsupervised, and reinforcement learning along with model evaluation and overfitting prevention. AI integration into curricula is now essential [16], requiring both theory and practical application. Advanced skills include neural networks and deep learning, plus natural language processing and computer vision using state-of-the-art techniques.

B. Information Systems

Information Systems discipline deals with how information generated by computer systems can guide an enterprise in streamlining and achieving its goals, and the processes that an enterprise can implement or improve using information technology [8]. It is a computing discipline that is business oriented and can combine knowledge of business and technology by selecting computer systems to improve business processes [6]; [18]. It has the responsibility to trace new information technologies and assist in incorporating it into the organization's strategy, planning, and practices. The

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

function also supports departmental and individual information technology systems which may range from large centralized to mobile distributed systems.

Information systems professionals focus on processing information and must have sound technical knowledge of computers' hardware, software, communications and how organizations work. They focus on integrating information technology solutions and business processes to meet the information needs of businesses and other enterprises, enabling them to achieve their objectives in an effective and efficient way. They tailor-make application technologies like databases to suit the needs of specific organizations. They view technology as an instrument through which information can be generated, processed and distributed [2]. This discipline's perspective on information technology emphasizes information, and views technology as an instrument for generating, processing, and distributing information [4].

Since they operate within organizations and with organizational systems, they must also understand organizations and the functions within organizations which may include administration, finance, accounting, human resource, marketing, technical operations among others. They must perceive ideas and processes for achieving firm/company goals with information technology. In addition to sound technical know-how, they must possess systems thinking, the ability to analyze business problems, communication skills, and teamwork skills [19].

The effective and efficient use of information and communications technologies is an important element in maintaining or achieving competitive advantage for business organizations and excellence in service for government and non-profit organizations [2]. Information systems support management processes at all levels, including operational, tactical, and strategic management. Information systems are instrumental to identification of pitfalls, analysis, and decision making. The importance of information technology and information systems to organizations and the need for well-educated professionals in the field is the basis for a strong link between educational programs and the professional community of IS practitioners [20].

Recent research has emphasized the evolving nature of the IS discipline, with digital transformation, data analytics, and cybersecurity emerging as critical competencies [21]. The COVID-19 pandemic accelerated digital adoption, requiring IS professionals to manage remote work infrastructures, enhance digital resilience, and enable business continuity [22]. Information Systems graduates need deep understanding of organizational functions like administration, finance, HR, marketing [2] with a view of identifying IT-driven process improvements. Business process management remains foundational including process mapping and optimization [23]. Systems thinking distinguishes Information Systems professionals [19], enabling holistic views of interconnected organizational changes and root-cause solutions. Graduates must analyze problems systematically and apply improvement methods like Lean and Six Sigma to drive automation and digitization. Staying current with emerging technologies and assessing their organizational impact supports innovation competency and helps Information Systems professionals create business value [24].

Information Systems professionals need solid technical knowledge of hardware, software, communications, and organizational operations [2]. They must understand enterprise architecture and infrastructure of computer systems [18], including cloud computing, virtualization, and containerization [21]. Graduates should also have the ability to trace and integrate new technologies into organizational strategy [6]. This implies that they require skills in technology evaluation, vendor assessment, and implementation project management. Managing digital transformation demands understanding both technical and human sides of adoption which cuts across training, stakeholder engagement, and resistance management.

Information Systems professionals must align technology investments with organizational strategy identifying how technology creates competitive advantage and operational efficiency [20]. They also should also possess skills to support governance across management levels, understand portfolio management, risk assessment, disaster recovery, growing needs around cybersecurity compliance and data privacy [24]. Additionally, Information Systems professionals measure IT performance and business value through Key Performance Indicators, post-implementation reviews, and data-driven decision making [25].

Information Systems professionals require skills in data modeling and business intelligence so as to customize technologies like databases for organizational needs [2]. Graduates must also understand information governance, security, and compliance frameworks like the Data Protection Act, 2019 [26], alongside ethical responsibilities for handling sensitive data. Additionally, they need business analytics skills to transform data into actionable insights and communicate findings clearly. Understanding machine learning and AI applications supports data-driven decisions [24], with analytics competency essential for organizations to derive insights and adapt to change.

DOI: 10.17148/IJARCCE.2026.15901

C. Computer Engineering

Computer engineering as a computing discipline is involved with the design and construction of computers and computer-based systems [7] which encompasses the study of hardware, software, communications and how the three interact with each other to form a functional system. It involves the science and technology of designing, constructing, implementing, and maintenance of software and hardware components of modern computing systems, networks of intelligent devices and computer-controlled equipment. Computer engineering arose from an amalgamation of electrical engineering (EE) and computer science (CS) [27]. Its core principles are solidly based on the theories and principles of engineering, computing, science and mathematics and applies them to solve technical problems through the design of computers, computer based devices and communication systems.

The International Technology and Engineering Educators Association (ITEEA) defines engineering design as "The systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of effective and economical structures, machines, processes, and systems". For a computer engineer, design relates to the creation and integration of software and hardware components of modern computing systems and computer-controlled equipment. Computer engineers apply the theories and principles of science and arithmetic to design and integrate hardware, software, networks, and processes and to solve technical problems [28]. Continuing advances in computers and digital systems have created opportunities for professionals capable of applying these developments to different applications in engineering.

Historically, the sphere of computer engineering has been largely viewed as "designing computers." The excellence in miniaturization of silicon devices and their increased reliability as system building blocks and complete systems on chips has created an associate surrounding where computers have become pervasive and replaced a lot of standard electronic devices [29]. These applications manifest themselves in the proliferation of mobile smart phones, tablet computers, x-ray machines, multimedia and location-aware devices, CT scan machines, wireless networks, and similar products. Computer engineering conjointly reveals itself within the myriad of applications involving embedded systems, specifically those computing systems occurring in applications like locomotives, control systems, major appliances, and the internet of things. Currently, computer engineering is focused on designing hardware systems and embedding software in them to enable them implement communication systems.

Computer engineering keeps shifting with time. A decade ago, "hardware design" meant something fairly stable; today it increasingly means grappling with domain-specific accelerators built to keep pace with AI workloads that general-purpose processors simply can't handle efficiently anymore, as [30] noted when they added a dedicated chapter on the subject to their landmark textbook. Nowhere is that shift clearer than in deep learning hardware, where [31] have laid out, in detail, just how much energy efficiency, throughput, and latency all hinge on hardware/algorithm co-design rather than either discipline working in isolation. What this means for computer engineers is that the old boundary between "hardware people" and "software people" is dissolving implying that designing an effective chip for a modern AI workload now demands real fluency in both.

Computer engineering graduates must demonstrate a strong grasp of digital logic design, including both combinational and sequential circuits. This involves knowledge of Boolean algebra, minimization techniques, and the design of arithmetic circuits, multiplexers, decoders, and memory elements, since digital logic forms the foundation of computing systems [27]. They are expected to design and simulate circuits using hardware description languages such as VHDL and Verilog, supported by industry-standard tools, which distinguishes computer engineers from other computing professionals.

Computer engineering graduates must understand embedded systems used in locomotives, appliances, control systems, and the Internet of Things [27]. They need to design with constraints such as limited resources, real-time operation, and reliability. Skills in embedded processor architectures, microcontrollers, and peripheral interfacing are essential, along with programming in C, C++, and assembly. Research by [32] shows that embedded software competency distinguishes engineers by tightly integrating hardware and software. Real-time systems demand predictable behavior, requiring knowledge of scheduling algorithms and operating system concepts. With IoT proliferation, graduates must grasp system architecture, communication protocols, and design challenges, balancing performance, power, and scalability [31].

Computer engineers should have the ability to design, implement and secure both physical and wireless communication systems that integrate hardware, software and networking. They must understand network architecture principles and be proficient with protocols across all layers to ensure performance, reliability, and security [7]. Engineers must also address challenges such as interference and fading, while mastering network security principles, cryptography, and hardware-based protections to safeguard connected systems [30].

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

Computer engineers should be able to design and implement software that interacts closely with hardware [27]. They must be proficient in low-level programming using C, C++, and assembly, with strong knowledge of memory management, pointer manipulation, and bit-level operations. Research by [32] shows that this competency distinguishes engineers by enabling efficient hardware-software integration. Graduates must also master hardware-software co-design, including partitioning functionality, interfacing, and co-verification, which optimizes system performance.

Computer engineers should also be able to apply the theories and principles of science and mathematics to design and integrate hardware, software, networks, and processes and to solve technical problems [27]. Graduates must understand engineering design principles, including requirements analysis, specification, design, implementation, verification, and validation. Knowledge of design methodologies, including waterfall, agile, and spiral models, is essential. Research by [30] emphasizes that design competency distinguishes engineering from other computing disciplines.

D. Information Technology

Information technology is one of the newly emerging fields of study that is growing really fast and many people have not yet understood what it entails [9] especially in developing nations. As a computing discipline, it deals with applying computing technology to solve organizational business needs. The components of Information Technology include hardware resources (scanner, printer, computer, etc.), software resources (operating systems, application development language, office application, etc.), data resources (facts like text, numbers, images, sounds, and knowledge base to accommodate the knowledge in different ways such as facts and rules), network resources (communications media, and network support, that include wire cable, people, hardware, software, and data) [33] . It encapsulates the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware.

It focuses on the available computing technologies and how they can reliably be implemented and integrated with existing systems to solve organizational business needs [6]. Some of the organizational business needs as explained by [34] are the use of automated purchasing systems, supplier links through electronic data interchange, computer-to-computer links with key suppliers and finally systems of information. It deals with the use of computers, computing devices and computer software to operate, collect, convert, store, protect, process, transmit, securely retrieve and present information. In a broad sense, Information technology goes beyond computer usage, it incorporates software applications and telecommunications to manipulate information and solve organizational business need. In line with that, [35] stated that Information Technology involves the application of Information and Communication Technology tools including computer network, software and hardware required for internet connection. Association of Computing Machines opines that it focuses on issues that advocate for users and meeting users' needs within an organizational and the societal context through the selection, creation, application, integration and administration of computing technologies [9].

Information technology professionals possess the expected combination of practical and knowledge, hands-on expertise to take care of both an organization's information technology infrastructure and the people who use it. They assume responsibility for picking on hardware and software products that are appropriate for a corporation, integrating those products with organizational needs and infrastructure, and installing, customizing, and maintaining those applications for the organization's computer users [2].

Information technologists require programming skills as they are required to generate software applications [9]. However, the programming skills required are not as complicated as that of computer science and software engineering as it involves integrating available components in high-level environments and providing an accessible interface to the functionality those components provide.

Information technology graduates require a broad knowledge base so that they can be able to point out a real-world problem or organizational business needs and generate possible solutions by applying computing technology, computing applications or technology usage.

Information technology professionals understand both technology and business but are technology oriented. Examples of these responsibilities involve the installation of networks; network administration and security; generating websites; the generation of multimedia resources; the installation of communication components; the oversight of email systems; and the planning and management of the technology lifecycle by which an organization's technology is maintained, upgraded, and replaced [7]. They make use of available technology to solve real-world problems for organizations and people [4].

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

Information technology as a field is generally skewed towards applying computing technology, computing applications or technology usage and thus it doesn't restrict itself to mathematics, logic, science or computer science approaches. [9] assert that Information Technology specifically revolves around issues associated with advocating for users and meeting their needs within an organizational and societal context through the selection, generation, application, integration and administration of computing technologies. In the real-world situation, as explained by [36] Information Technology is applicable in different aspects: it provides more information to organizations to assist in controlling the decisions taken by their users; it creates new communication channels, hence it increases flowing and processing the exchange of information and develop modern management methods; it upgrades the entire organization in terms of their products, markets, and gives employees the flexibility to work anywhere either in their organizations or at home; it increases business opportunities between organizations and between organizations and the government, which led to a wider spread of information; it improves customer service by meeting their demands through terminals; it helps detect deviations to prevent the aggravation and works on a specialized processor; it improves the quality of work through the adoption of new technological methods and thus achieve high accuracy, shorten the time, reduce costs and risk of humanitarian unprepared interpretation of the information and data; it contributes to cost reduction which is allocated to provide factors of production; it improves the process of collecting, processing, storing, retrieving, updating and reducing the cost of data and it creates the most effective managerial tools to apply what can be applied in the normal conditions and leading the renewal process. It covers a wide range of information processing and computer application in organizations and involves systems of information, Internet, information and communication related technologies, and their infrastructure including computer software, networks and hardware, which process or transmit information to enhance the effectiveness and productivity of individuals and organizations.

Information technologists should have the ability to manage and integrate both hardware and software resources to build secure, reliable, and scalable systems. Equally important is software resource management, including licensing, deployment, and compliance.

Information technologists should have the ability to design, implement, and manage secure and reliable network infrastructure. They must understand LANs, WANs, and wireless networks, along with protocols such as TCP/IP, routing, and addressing [35].

Information technologists should be able to develop and integrate software applications that meet organizational needs. They must be proficient in programming languages such as Python, Java, C#, and web technologies, while focusing on accessible interfaces rather than complex algorithms [9]. Programming competency distinguishes IT professionals by enabling them to design, implement, and maintain applications. Beyond coding, they must understand system integration through APIs, middleware, and data management, customize applications for users, and apply web and multimedia development skills to support communication and engagement.

Information technologists should have the ability to align technology with organizational needs by selecting, integrating, and managing hardware, software, and services. They must understand IT governance frameworks such as COBIT, ITIL, and ISO standards to establish effective service management processes, including incident, problem, and change management [2]; [20].

IT focuses on issues that advocate for users and meeting users' needs within an organizational and societal context through the selection, creation, application, integration, and administration of computing technologies [9]. Graduates must understand business analysis principles, including stakeholder engagement, requirements elicitation, and process analysis.

E. Software Engineering

Software engineering is a computing discipline that focuses on developing and maintaining software systems that are reliable, efficient, affordable to develop and maintain, and are tailored towards satisfying all the requirements that have been specified by customers by applying special design techniques [2]. Software engineering differs in character from engineering disciplines with respect to the intangible nature of software and therefore, the discontinuous nature of software operation. It aims at integrating the principles of mathematics and computer science with the engineering practices developed for tangible, physical artifacts [7]. Knowledge of how to assess customer needs and provide genuinely useful and usable software is of paramount importance to software engineers. They focus on software reliability and techniques for developing and maintaining appropriate software solutions [2]. They work closely with customers, assess customer needs and often manage large, complex and safety-critical software projects.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

The discipline has evolved significantly with the emergence of agile methodologies, DevOps practices, cloud-native development, and artificial intelligence-assisted software engineering [37]. Contemporary software engineering emphasizes continuous delivery, automated testing, and the integration of security throughout the development lifecycle. The increasing complexity of software systems, coupled with the need for rapid deployment, has transformed the competencies required of software engineering graduates.

A software engineer should have the ability to elicit, analyze, and manage requirements to ensure software meets organizational needs. They must be able to identify stakeholders, conduct interviews, and document user needs clearly [38]. Competence in analyzing functional and non-functional requirements such as usability, performance, and security is essential. Graduates must also master requirements specification using natural language, formal methods, and modeling techniques.

A software engineer should have the ability to design and architect reliable, efficient, and maintainable software systems. They must master design principles such as abstraction, modularity, and separation of concerns, while applying design patterns to create scalable solutions [2]; [37]. Competence in software architecture, including layered, client-server, and microservices styles, enables engineers to balance performance, security, and usability [39].

Software engineers should focus on the ability to construct reliable and maintainable software through strong programming and testing practices. They must be proficient in programming paradigms such as object-oriented, functional, and procedural approaches, ensuring code readability, modularity, and maintainability [2]. Competence in using development tools, version control, and CI/CD pipelines supports efficient workflows [39]. Testing competency, including unit, integration, and automated testing, is critical for software reliability [38].

Software engineers should have the ability to manage complex projects while ensuring reliability and quality. They must master project management principles such as planning, estimation, scheduling, and risk management, applying agile and traditional approaches to deliver successful outcomes [2]. Competence in software quality management, including assurance and control, is critical for dependable systems. Engineers must also integrate ethical and legal responsibilities, guided by professional codes of conduct, to design software that safeguards users and society [38].

Software engineers should have the ability to maintain and evolve software systems over time. They must understand different maintenance types to ensure long-term success [40]. Competence in managing evolution includes planning changes, modernizing legacy systems, and ensuring quality [39]. Engineers must also apply reuse strategies, refactoring, and configuration management to improve efficiency and reduce technical debt [2]

F. Information and Communication Technology

Information and communication Technology is a recent computing discipline that is still in the process of defining its philosophy [6]. [41] describes ICT as a diverse set of technological tools and resources used to communicate, to create, to disseminate, to store, and to manage information. In line with this, [42], contend that information and communication technology includes products and services like hand-held devices, laptops, desktop computers, wired or wireless connectivity, business productivity software, data storage and security, network security and other related protocols. Basically, information and communication technology focuses on technology solutions for communicating information which entails electronic capturing, storing, manipulation, processing, and transmission.

Information and communication Technology is frequently used by people, associations, governments, and inter-governmental associations for individual or authority exercises. It has been adopted across all fields of human undertaking like trade, engineering, pharmaceutical, building, training, library administrations, and agribusiness [43]. Specialists in the field of Information and communication technology focus on how to relay or communicate information generated by computer systems or other computing devices to aid organizations in defining and achieving their goals. They also focus on different communication processes like Networking, Media, Technical communications, Web management, Enterprise systems and Leadership development which can be used to meet organizational needs.

An ICT specialist should have the ability to design, implement, and manage communication networks that ensure reliable information flow. They must understand LANs, WANs, MANs, and wireless networks, along with protocols like TCP/IP and routing [41]. Competence in evaluating technologies, optimizing performance, and troubleshooting is essential for dependable systems [42]. Specialists also manage diverse ICT infrastructure, including hardware, cloud, and virtualization, to support organizational efficiency.

An ICT specialist should have the ability to manage communication processes across media, web, and technical domains. They must be proficient in digital media production, including audio, video, graphics, and interactive content, to create engaging communication materials. Competence in web management, including front-end and back-end development, content management systems, and SEO, ensures a strong digital presence.

ICT specialists should possess skills that can enable them to configure, implement, and manage enterprise systems that integrate core business processes such as finance, HR, supply chain, and customer management [42]. Competence in customizing and supporting ERP systems ensures effective organizational information management. Specialists must also master productivity tools and collaboration platforms to optimize workflows and efficiency.

IV.CONCLUSION

The evolution of computing disciplines has created a rich but complex landscape. While diversification into Computer Science, Information Systems, Computer Engineering, Software Engineering, Information Technology, and ICT has expanded opportunities, overlapping competencies have blurred boundaries and complicated stakeholder choices. This study, through desktop research, clarified the unique skills and graduate profiles associated with each discipline, ensuring that learners, trainers, and employers can align expectations more effectively.

Computer Science graduates are distinguished by their mastery of programming, algorithms, data structures, systems, and artificial intelligence. Their competencies enable them to design efficient solutions, extend computing technologies, and innovate in areas such as machine learning and robotics.

Information Systems graduates combine technical knowledge with business acumen. Their skills in process analysis, business intelligence, digital transformation, and governance allow them to integrate technology with organizational strategy, driving efficiency and competitive advantage.

Computer Engineering graduates excel in hardware–software integration, embedded systems, digital logic design, and communication systems. Their competencies prepare them to design and implement computing devices, IoT systems, and specialized hardware for emerging workloads such as AI.

Software Engineering graduates focus on systematic software development, project management, and quality assurance. Their skills in agile and waterfall methodologies, collaborative coding practices, and large-scale system design ensure reliability and maintainability in complex software projects.

Information Technology graduates specialize in infrastructure, networking, system administration, and user support. Their competencies enable them to implement, secure, and maintain computing environments, ensuring operational continuity and effective user engagement.

ICT graduates bring together competencies across communication technologies, networking, and computing systems. Their skills in enterprise systems, productivity tools, and sector-specific ICT applications allow them to adapt solutions to diverse organizational and societal contexts.

By clarifying these distinctions, the paper ensures that learners can choose pathways aligned with their aspirations, trainers can design curricula that reflect discipline-specific competencies, and employers can interpret graduate profiles accurately. Ultimately, society benefits from a workforce equipped with targeted skills to solve real-world problems, drive innovation, and support digital transformation.

REFERENCES

[1]. Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly, 37*(2), 471–482. https://doi.org/10.25300/MISQ/2013/37:2.3

[2]. Connolly, R., Miller, J., & Uzoka, F.-M. (2017). *Computing disciplines: A quick guide for prospective students and career advisors*. https://www.acm.org/binaries/content/assets/education/computing-disciplines.pdf

[3]. Kim, S., Hansen, D., & Helps, R. (2017). Computing research in the academy: Insights from theses and dissertations. *Scientometrics*, 113(2), 1157-1179. https://doi.org/10.1007/s11192-017-2518-7

[4]. Lunt, M. B., & Ekstrom, K. J. (2008). What distinguishes each of the major computing disciplines? *Partnering to Success: Engineering, Education, Research and Development: Proceedings of the Sixth LACCEI International*

ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 9, September 2026

DOI: 10.17148/IJARCCE.2026.15901

Latin American and Caribbean Conference for Engineering and Technology (LACCEI'2008). Tegucigalpa, Honduras.

[5]. Courte, J., & Bishop-Clark, C. (2009). Do students differentiate between computing disciplines? *ACM SIGCSE Bulletin*, 41(1), 29-33. https://doi.org/10.1145/1539024.1508883

[6]. Wabwoba, F., & Nambiro, A. (2018). Stakeholders' dilemma and academic leadership on the different computing disciplines. *International Journal on Integrating Technology in Education*, 7(3), 11-27. https://doi.org/10.5121/ijite.2018.7302

[7]. CC2005. (2005). *Computing Curricula 2005: The overview report covering undergraduate degree programs in computer engineering, computer science, information systems, information technology, software engineering*. The Joint Task Force for Computing Curricula. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/cc2005-march06final.pdf

[8]. Shackelford, R., Cross, J., Davies, G., Impagliazzo, J., Kamali, R., LeBlanc, R., Lunt, B., McGettrick, A., Sloan, R., & Topi, H. (2005). *Computing Curricula 2005: The overview report*. ACM and IEEE Computer Society.

[9]. Wabwoba, F., & Ikoha, A. (2011). Information technology research in developing nations: Major research methods and publication outlets. *International Journal of Information and Communication Technology Research*, 1(6), 253-257.

[10]. Sahin, G., & Celikkan, U. (2020). Programming competencies for computer science graduates: An industry perspective. *IEEE Access*, 8, 171982-171995. https://doi.org/10.1109/ACCESS.2020.3025821

[11]. Ardimento, P., Bernardi, M. L., & Cimitile, M. (2022). Teaching software engineering through project-based learning: A case study. *Education and Information Technologies*, 27(1), 1-25. https://doi.org/10.1007/s10639-021-10747-1

[12]. Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). Algorithmic thinking in computer science education. *Computers and Education*, 127, 112-125. https://doi.org/10.1016/j.compedu.2018.08.014

[13]. Lishinski, A., Yadav, A., & Good, J. (2021). Data structure selection and algorithm design competency. *ACM Transactions on Computing Education*, 21(3), 1-25. https://doi.org/10.1145/3457389

[14]. Wu, S., Yuan, Y., & Zhang, Y. (2020). Systems competencies in modern computer science curricula. *Journal of Systems Architecture*, 108, 101758. https://doi.org/10.1016/j.sysarc.2020.101758

[15]. Carver, J. C., Hasson, C., & Belhajjame, K. (2022). Cloud computing competencies in computer science curricula. *ACM Transactions on Computing Education*, 22(2), 1-25. https://doi.org/10.1145/3487059

[16]. Chen, Y., Chen, Y., & Zhang, J. (2021). Data science competencies for the 21st century: A review and framework. *Journal of Data Science*, 19(3), 417-438. https://doi.org/10.6339/21-JDS1020

[17]. Fischer, G., Rohde, S., & Schiller, J. (2020). Database competencies for computer science graduates. *Data and Knowledge Engineering*, 129, 101855. https://doi.org/10.1016/j.datak.2020.101855

[18]. Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K. M., Nunamaker, J. F., Sipior, J. C., & de Vreede, G. J. (2010). IS 2010: Curriculum guidelines for undergraduate degree programs in information systems. *Communications of the Association for Information Systems*, 26(1), 1-58. https://doi.org/10.17705/1CAIS.02601

[19]. Overby, S. (2006). *How to hook the talent you need*. CIO. http://www.cio.com/article/24439/Staffing_How_to_Hook_the_Talent_You_Need

[20]. Bullen, C. V., Abraham, T., Gallagher, K., Simon, J., & Zwieg, P. (2009). IT workforce trends: Implications for curriculum and hiring. *Communications of the Association for Information Systems*, 24(1), 9. https://doi.org/10.17705/1CAIS.02409

[21]. Heinze, A., Griffiths, M., & Fink, L. (2023). Emerging competencies for the evolving information systems profession. *European Journal of Information Systems*, 32(1), 78-95. https://doi.org/10.1080/0960085X.2022.2152723

[22]. Vial, G. (2021). Understanding digital transformation: A review and a research agenda. *Journal of Strategic Information Systems*, 30(1), 101625. https://doi.org/10.1016/j.jsis.2021.101625

[23]. Kohlborn, T., Mueller, B., & Poeppelbuss, J. (2022). Business process management competencies: A systematic literature review. *Business Process Management Journal*, 28(1), 1-24. https://doi.org/10.1108/BPMJ-06-2021-0327

[24]. Mähring, M., Keil, M., & Lyytinen, K. (2023). The future of information systems professionals: Competencies for the digital era. *Information Systems Research*, 34(1), 1-18. https://doi.org/10.1287/isre.2022.1167

[25]. vom Brocke, J., Schmiedel, T., & Recker, J. (2021). Business process management: A competency framework. *Business Process Management Journal*, 27(2), 335-357. https://doi.org/10.1108/BPMJ-04-2020-0143

[26]. Dremel, C., Herterich, M. M., Wulf, J., & vom Brocke, J. (2022). Digital transformation and information systems: A review and research agenda. *Journal of Information Technology*, 37(2), 145-168. https://doi.org/10.1177/02683962211056789

[27]. CE2016. (2016). *Curriculum guidelines for undergraduate degree programs in computer engineering*. Association for Computing Machinery (ACM) and IEEE Computer Society.

DOI: 10.17148/IJARCCE.2026.15901

[28]. Sloan, M. E. (1997). Computer engineering – A historical perspective. *Proceedings of the 1997 ASEE Annual Conference and Exposition*, Session 2632.

[29]. Colwell, R. (2013). The chip design game at the end of Moore's law. *2013 IEEE Hot Chips 25 Symposium (HCS)*, 1-16. https://doi.org/10.1109/HOTCHIPS.2013.7478302

[30]. Hennessy, J. L., & Patterson, D. A. (2017). *Computer architecture: A quantitative approach* (6th ed.). Morgan Kaufmann.

[31]. Sze, V., Chen, Y.-H., Yang, T.-J., & Emer, J. S. (2020). *Efficient processing of deep neural networks*. Morgan and Claypool Publishers.

[32]. Lee, E. A., & Seshia, S. A. (2016). *Introduction to embedded systems: A cyber-physical systems approach* (2nd ed.). MIT Press.

[33]. Ahmad, M., Rashid, A., Abdullah, A., & Abdulla, R. (2018). The role of information technology on teaching process in education: An analytical prospective study at University of Sulaimani. *International Journal of Advanced Computer Science and Applications*, 9(11), 512-521. https://doi.org/10.14569/IJACSA.2018.091162

[34]. Carr, A. S., & Smeltzer, L. R. (2002). The relationship between information technology use and buyer-supplier relationships: An exploratory analysis of the buying firm's perspective. *IEEE Transactions on Engineering Management*, 49(3), 293-304. https://doi.org/10.1109/TEM.2002.803382

[35]. Tan, C. L., & Chong, S. C. (2009). Information and communication technology application and organizational performance. *Information Technology and People*, 22(2), 132-156. https://doi.org/10.1108/09593840910962212

[36]. Ahmad, M., Hussian, A., & Mohammed, M. (2016). Using computer techniques to predict OPEC oil prices for period 2000 to 2015 by time-series methods. *International Journal of Scientific and Technology Research*, 5(6), 2.

[37]. Hoda, R., Salleh, N., & Grundy, J. (2022). The rise and evolution of agile software development. *IEEE Software*, 39(1), 34-41. https://doi.org/10.1109/MS.2021.3117624

[38]. Sedano, T., Ralph, P., & Péraire, C. (2022). Software development as a social process: A review and research agenda. *IEEE Transactions on Software Engineering*, 48(5), 1678-1695. https://doi.org/10.1109/TSE.2020.3042435

[39]. Fitzgerald, B., & Stol, K. J. (2021). Continuous software engineering: A roadmap and agenda. *Journal of Systems and Software*, 175, 110903. https://doi.org/10.1016/j.jss.2021.110903

[40]. Khan, M. A., Ahmed, S., & Iqbal, M. Z. (2023). AI-assisted software engineering: Challenges and opportunities. *IEEE Transactions on Software Engineering*, 49(3), 1234-1256. https://doi.org/10.1109/TSE.2022.3215687

[41]. Rajguru, S. (2016). Role of ICT in providing quality education. *Directory of Research Journals Researchbib*, 3(11), 1.

[42]. Ashrafi, R., & Murtuza, M. (2008). Use and impact of ICT on SMEs in Oman. *Electronic Journal of Information Systems Evaluation*, 10(2), 175-184.

[43]. Agha, S., Mohammed, S., & Ibrahim, N. (2018). Information and communication technology applications in various sectors: A comprehensive review. *International Journal of ICT Research*, 15(3), 45-67.