Journal of Engineering Design and Analysis
Volume 3, Issue 2 - 2020, Pg. No. 78-84
Peer Reviewed Journal

Review Article

The Computing Profession, 4IR, Professionalism and Skills Development in the 21st Century

Ezekiel Uzor Okike[1], Barilee Baridam[2]

[1]University of Botswana, Gaborone, Botswana.
[2]University of Port Harcourt, Port Harcourt, Nigeria.

I N F O

Corresponding Author:
Ezekiel Uzor Okike, University of Botswana, Gaborone, Botswana.
E-mail Id:
euokike@gmail.com

How to cite this article:
Okike EU, Baridam B. The Computing Profession, 4IR, Professionalism and Skills Development in the 21st Century. *J Engr Desg Anal* 2020; 3(2): 78-84.

Date of Submission: 2020-09-20
Date of Acceptance: 2020-12-27

A B S T R A C T

Computing science as a discipline is playing a leading and useful role in the other professional and organizational disciplines of Arts and Humanities; Engineering and Technology; Law; Medicine; Education; Social Sciences and the Sciences. This is because of its leading application in all the other disciplines and organizational set ups. With the spate of new developments in the discipline and the era of the 4th industrial revolution 4IR, there is a huge challenge of skills development which needs urgent attention. This paper examines and expatiates on the main components of the computing profession, and presents an analysis of the main professional career and skills development direction required to meet the demands of the professional practice of computing and IT in the 21st century. A 3S model of Skills development, Staff training and retraining, and Self-tooling and retooling is suggested as starting point of skills development agenda in the computing profession.

Keywords: Computing Profession, Information Technology, Skills Analysis, Career Prospects

Introduction

Computing Science comprise of five main components namely Computer Science (CS), Computer Engineering (CE), Software Engineering (SE), Information Technology (IT) and Information Systems (IS).

Computer Science is the study of computers and computational systems. Computer scientists work mostly with software and software systems, as it relates to their theory, design, development and application.[23] Computer Science students study the nature and techniques of problem solving through computation. Understanding computation requires a knowledge of hardware, software, mathematics and logic.[12] According to Ralston, Reilly & Hemmendinger,[3] Computer Science is concerned with information processes, with the information structures and procedures that enter into representations of such processes, and with their implementation in information processing systems. It is also concerned with relationships between information processes and classes of tasks that give rise to them. From these definitions, Computer Science can be said to be about computers, computational systems, software, software systems, information processing, information structures, procedures, and information processing systems.

Computer Engineering (CE) integrates Electronics Engineering (EE) with computer science. Computer Engineers design computing components such as digital hardware and devices, and build networks for digital communication and data transfers among other things.

Software Engineering (SE) is concerned with all aspects of software production from the early stages of system specification through to maintaining the system after it has gone into use 11 SE describes the collection of techniques that apply an engineering approach to the construction and support of software products. The engineering approach of

SE implies that activities are well understood and controlled, so that there are few surprises as the software is specified, designed, built and maintained. According to Fenton & Pfleeger,[13] while Computer Science (CS) provides the theoretical foundations for building software, software engineering focuses on implementing the software in a controlled and scientific way (p.9) so that the resulting software may come out as reliable and acceptable as possible. Like other engineering disciplines, SE applies theories, methods, models and tools which ensure that a rigorous approach is followed in developing the software. In addition to addressing technical processes of software development, SE includes activities such as software project management, development of tools, methods and theories to support the production of quality software. In addition to addressing technical processes of software development, SE includes activities such as software project management, development of tools, methods and theories to support the production of quality software.[11]

Information Technology (IT) and Information Systems (IS) deal with the organizational needs and application of computing and computational processes. In this regard, IT also referred to as Information and Communication Technology (ICT) embodies a convergence of computing, electronics and telecommunication systems. It embraces the use of machines and services to solve information and communication needs through technological inventions involving media and broadcast, telecommunications equipment and services, network-based information services, IT equipment and services, Internet service providers, and related specialized professional services.[4], 9 Its components usually include.[6]

- Computing systems (Computer hardware and Software systems)
- Communication systems (telecom, telephone, Satellites, Telex, Facsimile, Internet/ email, Fax, Videotext, Document delivery)
- Reprographic systems (Micro-graphics, electronic copiers, Word processing and Desk Top Publishing (DTP))
- Microwave systems (Radio, TV)

Specifically, an Information Systems (IS) is a combination of hardware, software, infrastructure and trained personnel organized to facilitate planning, control, coordination, and decision making in an organization. Like IT, businesses need IS to operate today, and they use many different kinds of systems. IS specialists (like IT specialists) are responsible for organizational information systems operations. They ensure that hardware, software, and other technologies used by these systems are running properly and are up to date.

Furthermore, the business world today depends largely on IT which is directly responsible for adding values to businesses, and leveraging on IT as a tool for competitive advantage over rivals. Therefore, organizations seek business opportunities in the use of IT and also make investments in IT capabilities in order to achieve the following goals.[2]

- Reduction of cost, for example by automating routine tasks, administrative processes
- Improvement in management control, by developing and implementing a Management Information Systems (MIS) or a Decision Support System (DSS)
- Gaining competitive advantage over business competitors, for example by reducing product development time, improving market intelligence, information gathering and analysis
- Improvement of communication by using advanced communication facilities, networks, and electronic mailing facilities
- Provision of better service to customers through faster response to customer needs
- Improvement in the quality and functionality of products and services
- Introduction of innovation, and business redesigning by implementing modern planning systems, workflow management systems and introducing computer integrated manufacturing technologies

For these reasons, industrial and governmental organizations, and other institutions using computers will continue to need the services of computing professionals.

Problem Statement

The need for continued training and developing competent professionals in all aspects of the computing professions has been growing in geometric proportions as computing continues to evolve, and permeating all aspect of human, organizational and societal endeavors. From home computing to social computing, and from business computing to scientific and numerical computing there exist a continuum in actual professional role playing which demands that computing professionals must be available in the appropriate proportions to address any skill gaps in the profession anywhere and anytime. To achieve this, there is need for holistic action in computing human resources development. One of such approach is the focus of this paper.

Objectives

The main objective of this paper is to analyze the components of the computing profession, and to demonstrate the need for urgent skills development in the computing profession with a view to meeting the dynamic requirements in computational skills in the 21st century. Equally, the paper proposes a 3S model to aid the training and development of computing professional as role players in the computing profession.

ISSN: 2582-5607

Literature Review

Brief History of The Computing Science Discipline

The birth of Computing profession started with Computer Science as a discipline in the early 1930s with the works of Alan Turing1 and Kurt Godel, and the confluence of algorithm theory, mathematical logic and the invention of the 'stored-program' electronic computer.16 by the late 1940s, the writings of John von Neumann came as a demonstration of intellectual depth to the emerging discipline of computer science. Several other state-of?the-art works that heralded the birth of computer science and the resulting information sciences are the algorithms and programming language created by Ada Lovelace, the analog computers built by Vannevar Bush in the 1920s, and the electronic computers designed and built by Howard Aiken and Konrad Zuse in the 1930s.

From the growth and development of the discipline of computer science, it is evident that it evolved with - -machine concept involves the application of machines by humans to solve common human related problems; where the problems are classified by information and communication needs. The evolution of communication systems has also enhanced other computer-related specialties - computer systems, computer engineering, software engineering, information systems, and domain-specific? applications.

Computer Science and the other Disciplines

Computer science also focuses on the human-made processes with regards to the usage of information processing systems and machines for information coordination and communication. The tasks of information processing has merged computer science with other disciplines as there is a growing need of solving human's problems. computer systems are therefore used in these other fields of human discipline as tools for speedy processing of tasks, accuracy and reliability of output, safety, and dependability among other benefits.16 Some examples of other disciplines relating to computer science are bioinformatics - in molecular biology, medical science, psychology, geology, engineering, agriculture - plant and animal science, physics, humanities, and a host of others. Therefore, the computer science discipline encompasses two broad study categories: the study of information processing tasks with related data representations, and the study of strategies to process information using appropriate structures, mechanisms and schemes. Information processing deals with the applications, while the information processing strategy deals with the systems. From this, the relationships between computer applications and computer systems with their various tasks can be established: computer application tasks are of numeric and non-numeric categories. Numeric computer applications deal with numeric data and mathematical models supported by optimization, simulation and numerical data analysis. Non-numeric applications consider the representation of problems with symbols and rules. Examples of problems supported by non-numeric applications are information retrieval systems, combinatorial processes, artificial intelligence, language processors, multimedia systems, graphics, and database systems.

Categories of Computer Systems

Software and hardware systems are the categories of computer systems. Software systems involve machine-level representations of programs and data, systems programs (compilers, operating systems), schemes for controlling the execution of programs, and network communications and management. Hardware systems involve the physical components which involves the logical design, machine organization, processors, memory, and devices in various technologies such as VLSI and silicon of the computer system. Computer architecture and computer engineering adopt both software and hardware, while Computer Engineering (CE) integrates Electronics Engineering (EE) with computer science. Computer Engineers design computing components such as digital hardware and devices, and build networks for digital communication and data transfers among other things.

Skills Development and Professionalism In The Computing Profession

The various professional divisions of computing as presented in Table 1, is a huge market. There also exist professional organizations and societies that provide infrastructural support for these professionals. Below are elements of the infrastructure [10, 17, p. 2]:

- Professional education, initial and continuing
- Accreditation Standards of principles (body of knowledge)
- Standards of professional practice (competencies)
- Skills development
- Certification
- Licensing
- Code of ethics
- Professional specialty groups

Computer users look to computing professionals, (otherwise generally referred to as IT professional by non professionals) to help them with their needs for "designing, locating, retrieving, using, configuring, programming, maintaining and understanding computers, networks, applications, and digital upsurge in non? IT professionals seeking to understand how these are done, and how they can participate in doing them. Table 1, below presents the professional disciplines of computing, while Table 2, presents the skills gap concerns among IT industry firms in the US.

Playing and Professional Development in The Computing Profession

Role playing in the computing profession implies acquiring professional skills that enable one to play a role in any of the professional areas in the computing profession as programmers or system developers, database admini strators, systems analysts, network administrators, and other IT professional skills and specialties as presented in Table 1 and Table 2.

Table 1.Professional Subdivisions of Computing

Computing-Core Disciplines	Computing-Intensive Fields	Computing-Infrastructure Occupations
Artificial intelligence	Aerospace engineering	Blockchain administrator
Cloud computing	Autonomous systems	Computer technician
Computer science	Bioinformatics	Data analyst
Computer engineering	Cognitive science	Data engineer
Computational science	Cryptography	Database administrator
Database engineering	Computational science	Help desk technician
Computer graphics	Data science	Identity theft recovery agent
Cyber security	Digital library science	Network technician
Human computer interaction	E-commerce	Professional IT trainer
Network engineering	Genetic engineering	Reputation manager
Programming languages	Information science	Security specialist
Programming methods	Information systems	System administrator
Operating systems	Public Policy and Privacy	Web identity designer
Performance engineering	Instructional design	Web programmer
Robotics	Knowledge engineering	Web services designer
Scientific computing	Management information systems	
Software architecture	Network science	
Software engineering	Multimedia design Telecommunications	

Source.[17]

Table 2.Skills Gap Concerns among it Industry Firms

Skills gaps concerns among IT industry firms	Skills gap concerns among firms in other industry verticals
Data base/ Information management	Security/ Cyber security
Networks / Infra structure	Networks/ Infrastructure
Server / Data centre management	Data base /Information management
Security/ Cyber security	Server/ Data centre management
Help Desk/ IT support	Web design / Development
Data analytics/ Business Intelligence	Help Desk / IT support
Web Design/ Development	Data analytics/ Business intelligence
Application Development/ Programming	Virtualization
Storage/ Data back up	Enterprise Resource Planning (ERP)
Cloud Computing laas or Paas	Customer Relationship Management (CRM)

Source.[5]

ISSN: 2582-5607

Table 3.Perceptions of Factors That Contribute to It Skills Gaps

Factors	Micro Firms	Small Firms	Medium Firms	Large Firms	IT industry Firms	Non IT Industry Firms
Fast changing technology- difficult for IT workers to Stay current with skills	39%	49%	49%	48%	48%	45%
Lack of resources for IT skills development	45%	48%	39%	41%	38%	45%
IT education/training does not sufficiently translate to IT workforce performance	31%	35%	48%	44%	45%	36%
IT pay is too low in some areas	20%	33%	35%	28%	31%	28%
Difficult to conduct on the job training for IT workers	20%	25%	26%	20%	25%	22%
Competition for limited pool of skilled IT workers	16%	16%	22%	25%	26%	17%
Insufficient focus on STEM education	16%	16%	15%	14%	25%	12%
IT careers do not attract the best and brightest workers	10%	4%	12%	12%	16%	7%

Source.[5]

Essentially, every practitioner of the discipline possesses skills in four basic areas, namely: algorithmic intelligence, representation, programming, and design. Algorithmic intelligence is the ability to formulate actions by employing step-by?step procedures that give unambiguous results when carried out by a suitable machine. It resembles standard scientific thinking, which seeks to invent standard ways of observing a process that enables the reproduction of some standard procedures. Representation deals with the format of storage of data to efficiently answer questions that may arise therefrom. Programming addresses the ability to represent algorithmic thinking/intelligence and representations in form of codes for a software to perform some actions through the use of an appropriate machine. This programming skill includes a working knowledge of different programming languages (both low-level and high?level languages), program development tools, and operating systems. Design connects the previous three skills to the concerns of people, through the medium of systems that serve them. Design includes many "practical considerations such as engineering trade-off s integrating available components, meeting time and cost constraints, and meeting safety and reliability requirements" 16p 4. Table 3 presents the perceptions of factors that contribute to IT skills gaps in the United States of America (USA), the home of Computing and IT technologies.

IT Skills Gaps Analysis for Industrial Application

industrial trends. A skill gap analysis is a systematic review of the skills held by individuals in a company.24 According Dungan,21,19,22 the steps in skill gap analysis are identified as follows:

- Identify all skills required by an individual to carry out their job role effectively
- Identify and categorize critical and non critical skills required to achieve a higher standard of work
- Compare the list of required skills with the actual skills possessed by the individual employee
- Use the result of skills gap analysis to develop training plans, support performance appraisals and justify pay reviews
- Use the skills gap analysis to identify staff who have knowledge in particular areas as well as those who lack certain skills in order to facilitate mentoring within teams

Table 2, above shows skills gaps concerns among IT industry firms Vs Skills gaps concerns among firms in other industry verticals according to recent study in the United States of America. From the table the IT skills gaps concerns among IT industry firms as well as among other non IT firms are shown in the order of priority. All areas of IT skills gap identified require appropriate trainings through the universities and IT training institutes. Similarly, Table3 shows the factors that contribute to IT skills gaps in various types and sizes of firms. For small, medium and large firms, the highest rated factors affecting IT gaps skills are the fast changing rate of technology, the lack of resources for IT skills development and the fact that IT education does not sufficiently translate to workforce performance. The later

factor simply suggests that organizational workers need further professional IT trainings to fit the IT skills need of the industries as new technologies continue to emerge.

The 4th Industrial Revolution (4IR) and Skills Gap Requirements

Recent developments in computing has identified today's computing era as the 4th Industrial Revolution (4IR) which necessitates that IT human resource development to focus in the areas of fundamental concern with 4IR technologies. The areas of 4IR concerns area represented in figures 1 and 2 above. 20 With these developments, the need for urgent holistic measures in IT professional training and development to meet the skills gaps of today and the future cannot be overemphasized[7]. To address this need, a 3S formula is proposed.

S1: Skills development in the right direction of the envisaged need by academic and certificating institutions must emphasize:

- Quality and currency of academic programmes
- Quality measurement and management in ICT systems, processes, products and services

Practical evidence of efforts to address IT skills gap at the University of Botswana (UB) and author's research.

In line with the 3S formula, the following efforts support the use of the 3S formula

S1: Skills Development must emphasize:

1. Quality and Currency of Academic Programmes
    - UB CS Department has been very active

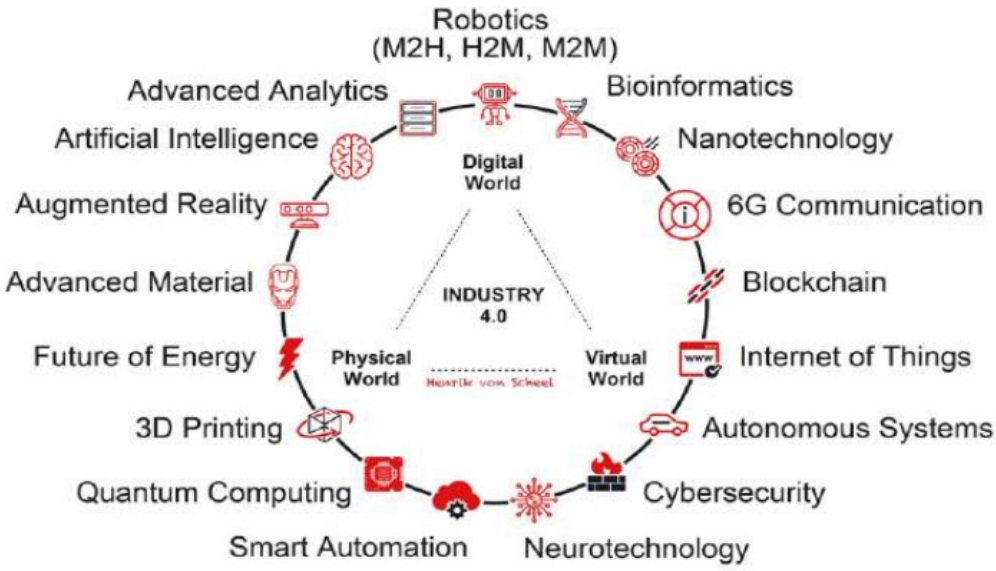

Figure 1. Areas of 4IR concerns

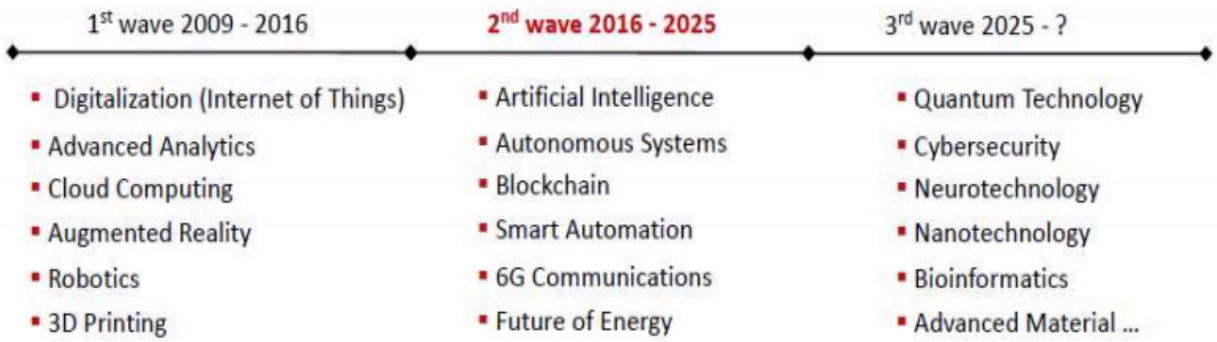

Figure 2.The 4IR waves

Proposal of A 3S Formula to Address it Skills Gap In The 21st Century

The proposed 3S formula addresses the following concerns:

S1: Skills Development in the right direction
S2: Staff Training and Retraining
S3: Self Tooling and Retooling

- Botswana Qualification Authority (BQA) also is playing vital role
- Botswana as a country also is taking ICT as an important focus

2. Quality Measurement and Management in ICT Systems, Processes, Products and Services

ISSN: 2582-5607

- Attention and focus on Quality Measurements and Metrics in research and academic programmes is vital
- Adherence to standards: ISO/IEEE/IEC standards must be emphasized.
- Application of Quality Metrics and Measures on ICT systems, processes, products and services has been the author's research endeavours.

Summary and Conclusion

The computing profession as discussed in this paper is the most dynamic profession. It is also the most useful profession to other professions as IT and ICT permeates all other disciplines. The need to develop adequate human resources with professional competence in all areas of the profession has been highlighted in this paper. A 3S model to enhance the professional development of the computing discipline has also been presented in order to enhance workplace knowledge and experience of IT and computing skills.

Furthermore, with the experience of IT skills training at the University of Botswana, Department of Computer Science, the 3S model has been justified. The Department pays attention to the quality of her academic programmes which also has the Botswana Qualifications Authority as overseeing body. In addition, the Department has a Professional Academy in partnership with international professional academies and testing centres for the following IT professional training skills namely Cisco Networking Academy, Microsoft Academy, SAP, Oracle and Pearson VUE in addition to the regular academic computing science programmes offered at both undergraduate and post graduate levels.

Therefore, to carter for the training needs of computing professionals in the 21st century, universities world-wide are beginning to create more specialty areas focusing on the perceived skills needs of the 4th Industrial Revolution as discussed above.

References

1. Turing AM. Intelligent machinery, a heretical theory, The Turing Test: Verbal Behavior as the Hallmark of Intelligence 105.
2. Stewart J. IT Infrastructure library: The Business perspective on your IT infrastruxture. *London*: H.M.S.O, 1996.
3. Ralston A, Reilly DE, Hemmendinger D, D. Encyclopedia of Computer science. 4th ed. *New York*: Willey, 2000
4. Baridam BB, Govender I. The role of information and communication policies in the governance of the healthcare sector, risk governance and control. *Financial markets and institutions* 2016: 31-35.
5. ComPTIA(2012). State of the IT skills gap. Full Report. URL. http://www.comptia.org
6. Okike EU. Understanding and Improving Information Technology infrastructure for e-business in Nigeria. Proceedings of the 17th National conference of the Computer Association of Nigeria (COAN). Sam Juwe, H. O. D Longe and A. D. *Akinde eds*. 2002; 12: 18-40.
7. Okike EU. Computer Science and Prison education. In Strategic Learning Ideologies in Prison Education programme. A volume in the Advances of Higher education and Professional Development (AHEPD) Book Series. *Ed. Idowu Biao* USA:IGI Global publishers 2017: 246-264.
8. Okike EU. The 4+ Industrial Revolution: Creating the future and managing the present. A presentation at the Computer Society of Botswana annual symposium 31 October, 2019. Unpublished.
9. GM Marcelle, " Getting gender into africanict policy: A strategic view" Gender and the Infromation Revolution in Africa 2000: 35-84.
10. Ford G, Gibbs NE. A mature profession of software engineering., Tech. rep., Carnegie? Mellon univ pittsburgh pa software engineering inst (1996).
11. Sommerville, Software Engineering. 9th ed.NewYork: Pearson, 2011.
12. MacEwan University, Computer Science Department (2015). Retrieved October 15, 2015 from http:// www.macewan.ca/computerscience/
13. Fenton NE, Pfleeger Sl, LS. Software Metrics. 2nd ed. *London*: PWS 1997.
14. Holmes N. Fashioning a foundation for the computing profession. Computer 2000; 33(7): 97-98.