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WESTERN CAPE

THE DEVELOPMENT OF A COMPUTER SCIENCE
CURRICULUM FOR THE HIGHER TECHNICAL AND
VOCATIONAL INSTITUTIONS IN LIBYA

by

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A thesis submitted in fulfilment of the requirements for the
degree of

Doctor of Philosophy

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Abstract

University of the Western Cape

Department of Computer Science

THE DEVELOPMENT OF A COMPUTER SCIENCE CURRICULUM FOR HIGHER TECHNICAL AND VOCATIONAL INSTITUTIONS IN LIBYA

Supervisor:

Professor Isabella M. Venter

The aim of the study was to develop a framework to align the Computer Science curricula of higher technical and vocational institutions in Libya with the curriculum as proposed by the Association for Computing Machinery, but in keeping with the realities of Africa. The graduate attributes, as suggested by the Association for Computing Machinery, were also considered and compared to the work experience of graduates of higher technical and vocational institutions in Libya. Design Science Research was used as the research methodology and both qualitative and quantitative methods were used to collect data. Semi-structured interviews were conducted with graduates from Libyan institutions and questionnaires were administered to employees from different companies and industries in Libya. The results of the investigation were used in the design of the artefact. The study found that in many cases graduates felt that they were not sufficiently prepared for the workplace as they did not possess the necessary graduate attributes. Skills such as abstract reasoning, team work and communication skills seemed to have been overlooked in the Computer Science curricula at tertiary institutions in Libya. It was also observed that the theoretical aspect of Computer Science was emphasised at the institutions and the acquisition of practical skills was

neglected. A framework was developed to assist Computer Science educators to track their compliance to the 2013 curriculum of the Association for Computing Machinery in terms of the acquisition of technical skills as well as the development of the necessary graduate attributes. The framework is an important contribution to the development of an internationally competitive Computer Science curriculum for Libya. It will allow Libyan institutions to focus on preparing students for a rapidly changing world.

Key words: Information communication technology; digital divide, Libya; higher technical and vocational institutions; computer skills; Computer Science; curriculum; developing country; design science research, graduate attributes.

ACM keywords: • **Social and professional topics~Model curricula** • **Social and professional topics~Computer science education** • *Social and professional topics~Computer and information systems training* • *Applied computing~Computer-assisted instruction*



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DECLARATION

I, *Hamzh Alaiat*, declare that *the development of Computer Science curricula for higher technical and vocational Institutions in Libya* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full name:

Date: November 15, 2019

Signed: _____



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GLOSSARY

ACM: Association for Computing Machinery, founded in 1947, is the largest and oldest international scientific and industrial computer society. Through its many Special Interest Groups, the *ACM* fosters research and communication in a broad range of computing areas (<https://whatis.techtarget.com/definition/ACM-Association-for-Computing-Machinery>).

Applied computing: Using aspects of Computer Science to solve problems in other disciplines such as: business, politics, the environment and education ([https://learn.org/articles/What is Applied Computing.html](https://learn.org/articles/What_is_Applied_Computing.html)).

Computer science education: A field of education that involves the study of computing, computation and programming in relation to computer systems. (<https://blogs.kel.ac.uk/cser/2016/03/04/what-is-computer-science-education-all-about/>).

Computer-assisted instruction: A program of instructional information and material that is presented via computer and computer systems (<https://www.igi-global.com/dictionary/computer-assisted-instruction-cai/5110>).

Computer-managed instruction: An instructional strategy where computer systems are used to provide learning objectives, resources and assessment of student performance (<http://ashimadeshmukh.tripod.com/page6.html>).

CS: Computer Science is the study of the theory and experimentation which is the basis for the design and use of computers.

CSS: Cascading Style Sheets is the language for describing the performance of Web pages, including fonts, layout, colours (<https://techterms.com/definition/css>).

DSL: Digital Subscriber Line is a technology that transmits data over telephone lines.

FTTP: First Fibre-to-the-Premises network architecture that uses optical fibre to provide local loops for last mile telecommunication (<https://www.makeuseof.com/tag/whats-difference-fttc-ftp-care/>).

GDP: Gross Domestic Product the monetary value of finished services and products produced within a particular country at a particular time period (<https://www.investopedia.com/terms/g/gdp.asp>).

GNI: Gross National Income the total domestic and foreign output of a country and it is composed of GDP and incomes earned by foreign citizens (<https://www.investopedia.com/terms/g/gross-national-income-gni.asp>).

GPTC: General Post and Telecommunications Company is a government owned corporation that oversees postal and telecommunication services in Libya.

HDI: Human Development Index is the detailed statistics on the life expectancy, education, per capita income among other indicators as used to rank a country's human development (<http://hdr.undp.org/en/content/human-development-index-hdi>).

HTML: is the language used to present Web pages on the Internet.

HTVI: Higher Technical and Vocational Institutions of higher learning after secondary school and they award higher diplomas and degree qualifications.

ICT : Information and Communications Technology is the unification and integration of telecommunications such as software and hardware (<https://techterms.com/definition/ict>). The term ICT is also used to reference to communication devices or applications such as radio, television, cellular phones, computer and network hardware and software, satellite systems, among others but also to refer to various services and applications associated with them, such as video conferencing and distance learning (Rouse, TechTarget, 2015). However, in this thesis ICT is used to refer to the unification and integration of telecommunications.

IEEE: Institute of Electrical and Electronics Engineers. It is a global association and organization of professionals working toward the

development, implementation and maintenance of technology-centered products and services (<https://www.webopedia.com/TERM/I/IEEE.html>).

Interactive learning environments: A system developed in software and specialised hardware intended to assist and support teaching and learning in education (https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-1428-6_321).

IS: Information system refer to the study of systems with specific reference to information and the complementary networks of software and hardware that people and organizations use to collect, filter, and process, create and also distribute data.

ISP: Internet Service Provider is organizations that provide Internet resources for private or commercial purpose.

IT: Information Technology is the use of any computer, storage, networking and other physical devices, infrastructure and processes to create, process, store, secure and exchange all forms of electronic data (<https://techterms.com/definition/it>).

LTT: Libya Telecom and Technology. This company provides Internet connectivity to 5.6% of the country's approximately 6.3 million citizens.

Model curricula: It is a model of the curriculum that is designed to plan for learning. It outlines the content knowledge that students need to acquire and defines the interaction between teachers and students (<https://www.slideshare.net/CarlRichardDagalea/curriculum-models-and-types>).

PHP: is defined as an HTML-embedded scripting language that is used to write web pages (<https://techterms.com/definition/php>).

UNESCO: The United Nations Education, Scientific and Cultural Organization. An organisation whose purpose is to promote peace and security by establishing international collaboration through cultural, scientific and educational reforms so as to increase universal respect for justice (<https://www.britannica.com/topic/UNESCO>).

WiMAX: Worldwide Interoperability for Microwave Access is a telecommunications protocol describing fixed and fully mobile Internet

access services. The protocol conforms to certain parts of the IEEE 802.16 Standard (<https://searchnetworking.techtarget.com/definition/WiMAX-Worldwide-Interoperability-for-Microwave-Access>).



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Chapter 1

STATEMENT AND ANALYSIS OF THE PROBLEM

Sketching the background

Technology has advanced so much in the last 50 years, that life or work without technological devices is almost impossible to imagine. Technology has transformed the way in which business is conducted but also the manner in which pedagogy is practiced. To be able to cope with change, tertiary education should be focused on training and educating a workforce that is flexible and able to adapt to the ever-changing technological work milieu. Most work activities in the information age deal with the abstract manipulation of symbols, which would not be possible without sophisticated software and fast powerful computers (Zuboff, 1988). Computer Science (CS) despite its short history has contributed greatly to the development of the Internet – the basis of the information age.

Computer Science students—who will be the future innovators and developers of software—thus need to be at the cutting edge of technology and must have the scientific grounding to be able to cope with change. CS as a discipline was, according to Odedra *et al.* (1993), in recent years, the growth of mobile phone networks has transformed communications in sub-Saharan Africa, thus making it possible for the African population to skip the landline stage of development and quickly shift into the digital age. The Sub-Saharan Africa's smartphone penetration was 33% in 2018, significantly higher than the 15% recorded in 2014, and market analysts predict this will double by 2025 (Matinde, 2018). According to Smith (2015) the most popular activities for the mobile phone users in Africa include sending text messages and taking pictures or videos, while other activities, such as getting political news, accessing a social networking site, getting health and consumer information and looking for a job, are less common (Smith, 2015).

The oil and gas industry in Libya is playing an important role in its economy, accounting for approximately 70% of its Gross Domestic Product (GDP). However, Libya is not at the forefront of technological development (Gelvanovska, Rogy, & Rossotto, 2014). According to Abuhadra & Ajaali, (2014), Universities in Libya offer CS as a subject, however, it has been noted that students do not leave the university prepared for the workplace (Khail & Halis, 2017). Therefore, it is important to address this issue by revising or improving the CS curriculum in Libya, to be in line with the needs of the workplace and to equip Libya’s people with skills that will enable them to participate fully in society and compete globally (Cackler, Gu, & Rodgers, 2008; Triki, 2016) .

Table 1: Education system in Libya

	Level	Years	Academic Qualifications		
School	Primary school	6	Medium Diploma		
	Primary secondary	3			
Secondary School Qualifications	Specialized secondary schools (4 years)	3			School leaving certificate
	Vocational qualification	1			
Higher Education Undergraduate	University	High technical and vocational institution	3	Bachelor Degree (4 years)	Vocational Diploma (3 years)
		Specific higher institution	1		Convert Diploma to degree
Advanced Studies Postgraduate	Masters degrees		2	MSc	
	Doctoral degrees		3	PhD	

Curricular reform for technical and vocational education in Libya will undoubtedly make a contribution to the advancement of the nation’s social and

economic growth. Currently, Libya has nearly 382 institutions which offer technical education at various levels providing education to more than 160,000 students across several disciplines (Impes, Othman, Wilson, & Pislaru, 2014). Bachelor degrees can be taken by students who have already obtained their secondary school certificate (Othman, Kashadah, Gosbi, & Khoja, 2012). Advanced studies are offered after the completion of a university or higher vocational education, and these include postgraduate diplomas, Master's Degrees and Doctor Degrees in various specializations (Tamtam, Gallagher, Olabi, & Naher, 2011). The schooling and university system in Libya is depicted in Table 1.

According to Rhema *et al.* (2013), the use of information technology (IT) by the general public in Libya is minimal, and this applies to the education sector as well. Students, and even some educators, in Libyan schools are either computer illiterate or have had little exposure to computers. This will need to change to better prepare high school pupils for university. The level of basic computer related knowledge is even lower in Higher Technical and Vocational Institutions (HTVI) in departments other than in CS departments (Rhema, Miliszewska, & Sztendur, 2013).

According to Impes *et al.* (2014), curricula and study plans of Libyan institutions are lacking the necessary content to be relevant in this fast-changing paradigm (Impes, Othman, Wilson, & Pislaru, 2014). Employers require that graduates have skills such as: good communication skills; problem-solving skills; critical and analytical thinking; ability to work in a team; willingness to learn; good interpersonal skills; ability to work in a modern organization and; graduates who are knowledgeable. These so-called graduate attributes can be developed in CS graduates if the CS curriculum makes provision for them (Roach & Sahami, 2013).

Many of the current difficulties in terms of education can be attributed to the civil war in Libya. This war destroyed Libya's once viable economy, leaving its telecommunications sector in tatters—and thus making it often difficult to access the Internet. It is estimated that more than \$1 billion worth of the telecom infrastructure was damaged during the civil war. Telecommunication in Libya, in spite of the war, is still superior when compared with most African countries, because the former regime ploughed substantial funds into a national fibre optic backbone (Business Wire, 2017). The regime extended digital subscriber lines (DSL) and developed worldwide Interoperability for microwave access (WiMAX) broadband services. Furthermore, the government installed new trans-national fibre connections, and improved existing connections. Libya, already in 2010, had one of the first fibre-to-the-premises (FttP) deployments and received its first terabit international fibre optic cable with the second fibre optic cable installed in 2013 (Business Wire, 2017). In addition, \$10 billion investments were earmarked for the development of telecommunications infrastructure up to the year 2020 (Budde, 2015). As can be seen in Figure 1 several undersea cables are being planned for the African continent and will provide more access to broadband in the future (Song, 2019).

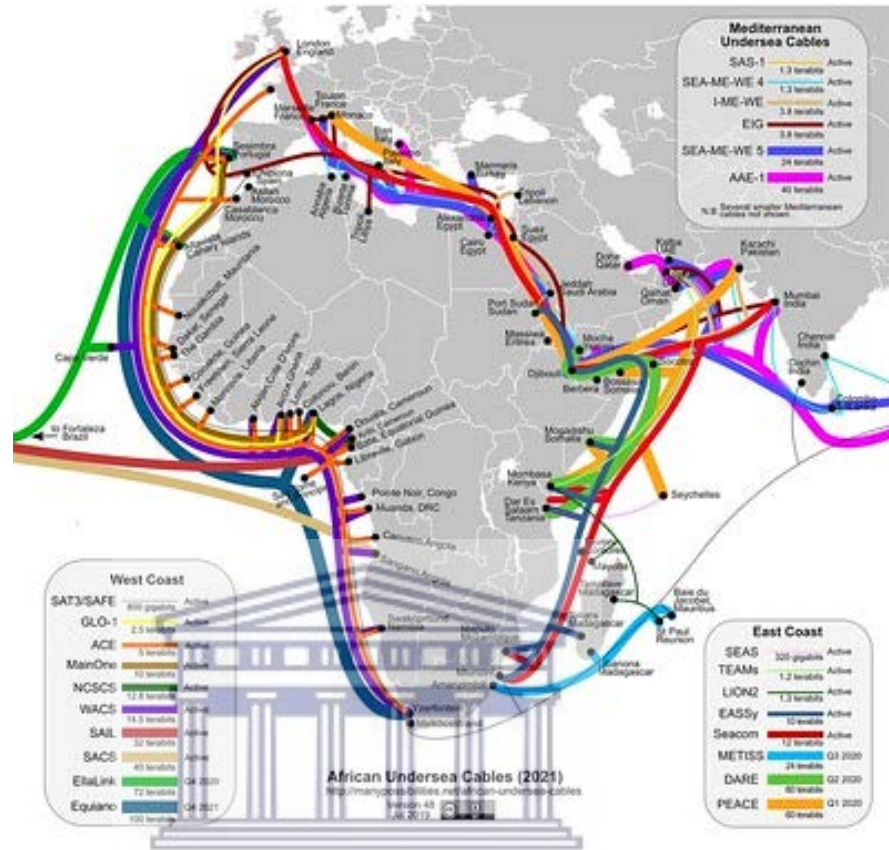


Figure 1: African undersea cables (Song, 2019)

Today in Libya, most people use Internet cafés to access the Internet – it is very expensive especially for students. The General Post and Telecommunications Company (GPTC) controls and operates most of Libya’s telecommunications infrastructure and the state owns and controls the nation’s primary Internet service provider (ISP), Libya Telecom and Technology (LTT), offering Internet services to people through dial-up, DSL, broadband and satellite. There are seven licensed ISPs but because the LTT controls and maintains the country’s national gateway, they are not independent. According to Elzawi *et al.* (2013), because Libya had almost no debt in 2010, it was able to establish an exceptional Information and Communications Technology (ICT) communication infrastructure (Elzawi, Kenan, Wade, & Pislaru, 2013).

The number of Internet users in Africa is considerably lower compared to the rest of the world (Andreasson, 2015). Statistical data collected in 2018 by the Internet World Stats, has shown that there are over 4.2 billion Internet users globally. This corresponds to 55.1% of the total world population. In Africa, there are approximately 525 million Internet users. With a population of over 1320 million people in Africa, the number of Internet users equates to a 39.8% penetration rate. However, this is way below the penetration rates of other continents. Asia is the only continent with a penetration rate close to that of Africa at 51.9% with the rest of the continents recording a greater penetration rate: Europe (86.8%); Latin America/Caribbean (68%); Middle East (67.2%); North America (89.4%); Oceania/Australia (68.4%). Therefore, considerable work still needs to be done to ensure that African Internet connectivity and penetration rate is on a par with other continents (Internet World Stats, 2019).

In most African countries, the Internet is expensive and made available mainly in the urban areas (Andreasson, 2015). Being able to access the Internet gives students as well as educators the ability to do research and consider the latest developments in the field.

Research question

When considering the tertiary education programmes in Libya in Computer Science the question is:

How should the Libyan Higher Technical and Vocational Computer Science curriculum be transformed to be aligned with international trends?

This question can be translated into the following sub-questions:

- What graduate attributes must be acquired by Computer Science students?
- What attributes does the workplace require from Libyan graduates?

- How does the curriculum of Libya align with the curricula from other countries and the ACM/IEEE?
- What factors would contribute to the development of specific graduate attributes?

Research aim

The aim of this research was to develop a framework to align the Computer Science curricula of higher technical and vocational institutions in Libya with the curriculum as proposed by the ACM. This was done by exploring how the CS curricula is interpreted by the Higher Technical and Vocational Institutions and to propose how it can be improved and aligned with international trends while keeping in mind the realities of Africa. A framework was developed and an on-line system programmed so that academics can evaluate their CS offering measured against this framework.

Research design

The Design Science Research (DSR) methodology was used for this research as it entails both a cyclical research methodology as well as the development of an artefact. The theoretical and practical knowledge contribution of CS education using design science research methodology has been alluded to (Venter, de la Harpe, Ponelis, & Renaud, 2015). Further, both qualitative and quantitative methods were used within this methodology.

Ethics

The methodology and ethics for this research were approved by the Research Ethics Committee of the University of the Western Cape (UWC) with ethics reference number – 15/7/238 (see Appendix A).

Research contribution

The contribution of this research is that it critically analysed the CS curricula in institutions of higher learning in Libya with the aim to aligning these CS curricula with the curriculum recommended by the ACM, keeping in mind the African context. An artefact (framework) was developed which can be used by CS educators in Libya, as well as other countries, to track their compliance with the recommended ACM CS curriculum.

Summary

This thesis is organised as five chapters. The first chapter introduces the subject matter of the thesis and sketches the background of the study regarding the problem of the content of CS curricula in Libya. In this chapter, the research aim and research questions are also posed. In Chapter 2 the literature regarding this study is reviewed, based on key words and concepts that are defined and specific to this field of research. The literature review looks at published articles and accredited websites in the field of curriculum design and CS education. In Chapter 3 the research design and methodology is discussed. It focuses on the: research approach, research instruments and data collection methods. Data Science Research is dealt with in detail and there is an explanation of how it has been adapted for this research effort. Chapter 4 is dedicated to the results of the research and presents the framework that this researcher developed so that academics can evaluate their CS offering and compare it with international curricula. In Chapter 5 the results, the contribution and future research are discussed.

Chapter 2

LITERATURE REVIEW

Introduction

In the previous chapter, the scope of the study was discussed. The background information in terms of the problem of the development of CS curricula in developing countries—more precisely in Libya—was explored and the rationale for the research approach and the research questions were briefly mentioned. Moreover, the thesis outline was presented. In this chapter the literature will be discussed in terms of the research questions that were posed, as well as the keywords that were defined, in Chapter 1. A review of the education system in Libya is provided and it covers the HTVIs and the CS curriculum currently in use. Additionally, the curricula of the Association for computing machinery (ACM) and Institute of Electrical and Electronic Engineers (IEEE) are discussed with specific reference to the ACM/CS curriculum recommendations.

Computer science education

Computer science education primarily focuses on the study of theoretical and experimental engineering that is the basis of the design and usage of computers. Hence, it is the science of a practical approach to computation and its applications in the acquisition, representation, processing and storage of information. Computer Science education can be divided into a number of theoretical and practical disciplines focused on making computers and on the extension of computation that is useful and universally accessible to all humanity (Roach & Sahami, 2013).

Information systems

Information systems (IS) have been defined as a study which focuses on the application of computing technology to simplify and solve business related problems. Figure 2 shows the application of IS as defined by the ACM (Major Fields in Computing, 2017).

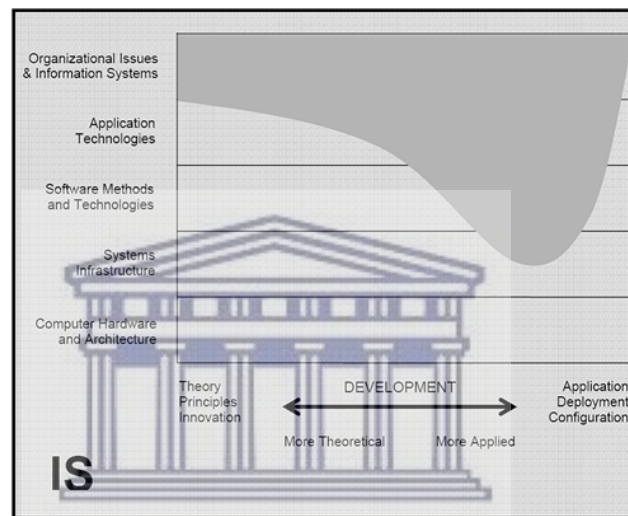


Figure 2: Depiction of how Information Systems is defined by ACM (The Association for Computing Machinery (ACM), 2005, p. 19)

Computer- and information systems training in Libya

Computer- and information-systems training in Libya can be achieved in three different ways: via full-time certificate level training, via online training or through continuous education. All these streams require high school diplomas or equivalent qualifications. Via the certificate level training, the training can be done through higher technical and vocational institutions or through a university. In HTVIs, the trained individual is awarded a college diploma whereas in a university, the individual is awarded an undergraduate or postgraduate certificate, depending on their level of qualification (Tamtam, Gallagher, Olabi, & Naher, 2011). Online training has emerged as another stream of training where students

attend online classes and only meet physically with the course instructor occasionally. This is especially suitable for individuals who reside far from an institution of learning. Continuing education involves staggered learning timetables, where the students pursue their learning in breaks. This stream is convenient for working professionals who cannot afford to attend classes for a continuous prolonged timespan (Rhema, Miliszewska, & Sztendur, 2013).

Computer-assisted instruction

This is an instructional approach that uses a computer to communicate the content and evaluate the student's responses. It uses a blend of texts, graphs, sounds and videos for the learning process (Suleman, Hussain, Naseer Ud Din, & Iqbal, 2017; Suppess, 2014). CAI tools enable school administrators to manage the instructional and learning process in education.

Across several studies reviewed by Nortvig *et al.* (2018) , they have found that e-learning or blended courses (that is, courses that combine e-learning with face-to-face teaching) should be constructed to advance the unity of online and offline activities. However, their research has confirmed that teaching and learning are so complex that not only the teaching format but many more factors should be considered to determine which format is the best.

Information and communication technology in Libya

Currently, ICT is utilized in almost all aspects of human activity. However, the rise of ICT use has led to an intense debate on the contribution of this technology towards productivity and growth on the one hand, and human welfare on the other in both developed and developing countries. It is a well-known fact that ICT has played an important role internationally with respect to globalization, by not only urging societies to build communications systems and manage them well, but also

by developing infrastructure and the capacity to use it. Furthermore ICT is used to implement policy and regulation (Shade, O, & Samuel , 2012).

Developing country

A developing country also referred to as an underdeveloped or less developed country, is a nation that has a less developed industrial base and a low Human Development Index (HDI), with respect to other countries (Andreasson, 2015). HDI is a measure of assessing human development in terms of a long, healthy life, a decent standard of living and access to knowledge. Libya is ranked as a developing country according to the World Bank (The World Bank, 2017). In 2015, Libya’s HDI value was 0.716 (see Table 2).

Table 2: Libya’s HDI trends based on consistent time series data

	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2011 PPP\$)	HDI value
1990	68.5	14.0	3.8	22,856	0.681
1995	69.9	14.8	4.7	22,233	0.709
2000	70.5	15.7	5.6	21,652	0.732
2005	71.4	15.4	6.4	25,776	0.752
2010	71.8	14.0	7.3	29,143	0.756
2011	71.6	13.7	7.3	11,041	0.706
2012	71.6	13.4	7.3	21,688	0.735
2013	71.6	13.4	7.3	19,354	0.730
2014	71.6	13.4	7.3	15,360	0.719
2015	71.8	13.4	7.3	14,303	0.716

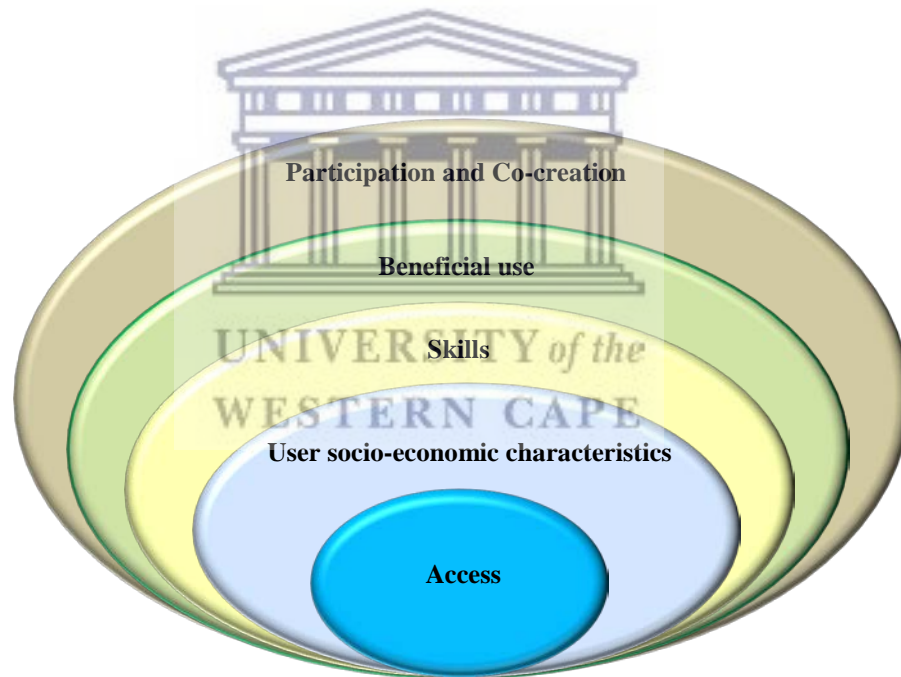
This was a slight drop from 0.719 in 2014. On average since 1995, the country’s HDI has been approximately 0.7 which puts the country in the high human development category, i.e. position 102 out of 188 countries and territories (UNDP, 2016). The country recorded a GDP per capita of 5449.03 US dollars with a growth rate of 8.10% against a global average of 3.1% (UNDP, 2016). The World Bank reported that growth has improved across the region and in the next few years most countries will identify new sources of non-oil revenue (The World Bank, 2018). Libya’s GDP grew by approximately 2% from -10.1% GDP growth

rate in 2015 to -8.1% in 2016. This trend is expected to continue as the country resumes oil production following the civil unrest of 2011 (Economics, 2016).

Digital divide

ICTs or digital technology continue to boost economic growth in many countries by expanding opportunities for individuals, communities and countries in improving service delivery. However, it ought to be noted that the average impact of these technologies has fallen short of expectation because they are unevenly distributed (The World Bank, 2016).

Figure 3 : Five levels of the digital divide (Andreasson, 2015, p. 16)



The digital divide can be defined to be the disparity in technology that exists such that some people, communities and even countries are underserved with technology whereas others have easy access (Rouse, WhatIs.Com, 2019). While there is a rapidly changing information society that is stimulated by the Internet, the old challenges such as varying rates of access and adoption of the Internet still

remain. This problem is also compounded by the emergence of new challenges as pointed out by Andreasson (2015). As can be seen in

, access to the Internet does not ensure that the users have the necessary e-skills for the beneficial use of the Internet, nor does it guarantee that they will eventually be able to participate and to co-create using the Internet.

Computer skills

Computer skills is defined as the knowledge and ability to use computers and related technology efficiently with a range of skills covering levels from elementary use, to programming and advanced problem solving (Leonard, 2018). According to Hbaci (2018), the majority of educators working at universities in Libya in 2018, lacked the computer-related skills required to incorporate computer technology into the higher education system. Although many participants had basic computer knowledge, they had little access to computer hardware and access to the Internet was limited. Students' experience of using Internet resources, external technology, and peripheral technologies related to current academic practices was also inadequate (Hbaci, 2018).

Higher technical and vocational institutions

At HTVIs, other than in the CS Departments, the level of basic computer related knowledge is still low (Rhema, Miliszewska, & Sztendur, 2013). However, even Libyan CS graduates, across the institutions, lack some of the skills required by employers (Triki, 2016). These skills include: analytical thinking, good interpersonal skills, problem-solving, good communication, willingness to learn, ability to work in a group and ability to work in a modern organization. These graduate attributes can be developed in CS graduates, if the CS curriculum makes provision for such development (Aithal & Kumar, 2015).

University and Higher Vocational Education

After successfully completing a specialized secondary education, students may enrol in university faculties that are relevant to their specialization, as indicated in their specialized secondary certificate (see Table 3). Higher education is free and students are also encouraged to enrol in HTVI institutions such as polytechnics, higher teacher training institutes, higher institutes for trainers, higher institutes of technical, industrial and agricultural sciences (Asma, Mustafa, & Hussin, 2017) .

Table 3: Higher technical and vocational institutions (HTVI) in Libya

	Level	Years	Academic Qualifications		
Higher Education Undergraduate	University	High technical and vocational institution	3	Bachelor Degree (4 years)	Vocational Diploma (3 years)
		Specific higher institution	1		Convert Diploma to degree
Advanced Studies Postgraduate	Masters degrees		2	MSc	
	PhDs degrees		3	PhD	

Some of the higher institutes have been converted into technical faculties which offer four years of learning and award technical Bachelor degrees in certain specialties. These institutions target students who have already obtained their secondary school certificate (Othman, Kashadah, Gosbi, & Khoja, 2012). Advanced studies are offered after the completion of university and higher vocational education, and these include postgraduate diplomas, Master's Degrees and PhD Degrees in various specializations and fields (Tamtam, Gallagher, Olabi, & Naher, 2011).

THE ACM AND IEEE CURRICULA

The Association for Computing Machinery (ACM) and the Institute of Electrical and Electronic Engineers (IEEE) (along with other leading scientific computing societies) have come up with curriculum recommendations for computing disciplines. Since new computing disciplines continue to proliferate and evolve, it is necessary to review existing curricular recommendations regularly to keep computing curricula current and relevant (ACM / IEEE-CS Cooperation, 2015). Since the last complete CS curriculum was released in 2001 (CC2001), an interim review was published in 2008 (CS2008) with the latest CS Curriculum CS2013, published in 2013. It is a comprehensive review and redefinition of the body of knowledge of CS.

Technology transfer requires educational changes in terms of connectedness; infrastructure and other related services as well as a need for the training of technicians and ICT experts. In 2010 UNESCO assisted with a curriculum review in Libya to ensure, at the time, that the Libyan ICT curriculum conformed to global ICT standards (Iwona Miliszewska, 2010).

Current computer science curricula in Libya

Higher education in Libya provides computer programmes and degrees. For example, there are courses in different disciplines such as Education in Computers, Computer Science, Computer Networks Software Engineering, Information Systems and Information Technology. Computer Science courses provide an education targeting the computing profession. Students learn to use Mathematics, Science and economics, along with technological knowledge and skills in the application of programming languages and software processes, to design, analyse, implement and test software systems and applications (Omicsonline.org, 2019).

In an effort to standardise the reform of programs and curricula, there has been a shift from the traditional way of developing and approving curricula to a much more centralized system for higher institutions (Othman, Kashadah, Gosbi, & Khoja, 2012). This centralised system ensures that teaching methods are standardised as opposed to traditional ways, in which teaching members of staff have tended to use summarised material rather than referenced curricula. This is primarily because of the expense involved in acquiring referenced materials, even though a book subsidy policy exists, which has been adopted by individual institutes and universities. Another problem that is avoided when the centralised system is used is the elimination of the effects of language barriers of the teaching staff when developing the curriculum. A limited understanding of the English language, especially in Libya where Arabic is used, puts a restriction on the materials that teaching staff members can use, because most teaching materials are predominantly written in English. In a centralised system, professional translation services can be used and these services aid access to a greater range of materials. Two of the most important resources to use when reforming a CS curriculum are the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronic Engineers (IEEE) (Roach & Sahami, 2013).

Graduate attributes

Graduate attributes are defined as the qualities, skills and understanding that students should acquire during the period of their studies at an educational institution. These attributes are usually recommended by a university community with the aim of helping the students to make a contribution to their profession and society. Furthermore, these qualities also play a role in the preparation of graduates as future agents of social good (Simon C & Barrie, 2004). This question is thus “What graduate attributes should be acquired by Computer Science students”? According to Rai *et al.* (2013), the skills and graduate attributes that African industrialists look for, include, good communication skills, the ability to

handle practical problems, problem solving skills and the ability to work independently. Specifically, Libyan employers are looking for graduates who are knowledgeable, have good interpersonal and communication skills, can critically and analytically assess situations, are able to work in a team setting and most importantly, who are willing to learn (Impes, Othman, Wilson, & Pislaru, 2014).

The workplace in Libya requires certain attributes from the graduates that they hire. According to Triki (2016), Libyan graduates are required to be able to apply their knowledge, i.e. they must be technically savvy, be able to solve complex problems without having to rely on theoretical knowledge only. Additionally, when analysing problems, they ought to do so logically. Graduates are also required to act ethically and professionally at their workplace. Effective communication skills are another requirement that employers look for. With respect to projects, graduates are expected to be able to manage projects effectively (Leonard, 2018).

Summary

To conclude, the defined key words were examined in detail in this chapter and the literature regarding the research questions was also dealt with. In the next chapter the research approach, research methodology and research methods used for the study will be motivated and the specific research design for this study will be discussed.

Chapter 3

RESEARCH DESIGN AND METHODOLOGY

Introduction

In the previous chapter, the literature was reviewed in terms of the keywords and the research questions posed. This chapter will present the research approach as well as the research design.

Approach

According to Crotty (1998) an epistemology determines a specific theoretical perspective, the choice of a methodology, which in turn entails several methods (as depicted in Figure 4).

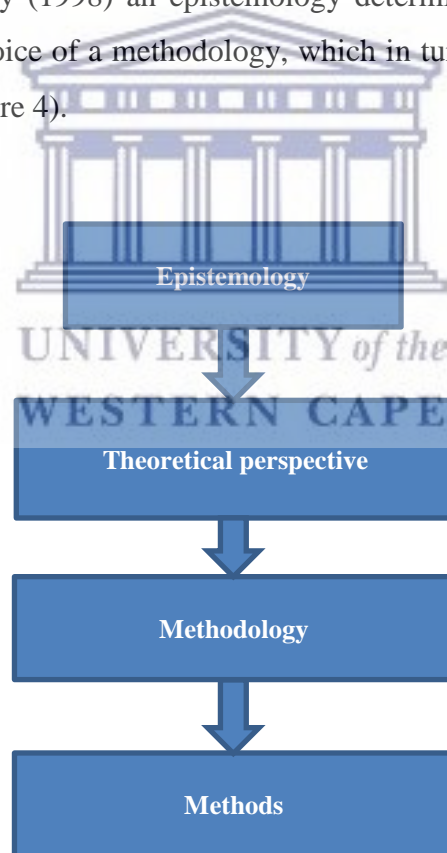


Figure 4: Research approach (adapted by Crotty, 1998, p.4)

EPISTEMOLOGY

Epistemology is the nature of the relationship between the knower/would-be-knower and what is known. Epistemology deals with providing a philosophical grounding used to decide what kind of knowledge is possible and how the researcher can ensure the information is adequate and legitimate (Crotty, 1998). Epistemology is related to ontology which is “the nature of reality.” One such ontological notion is constructivism, which is relativist, subjectivist and transactional. *Relativist* means that there is no objective truth to be known and as such an emphasis on the application of the diversity of interpretation to the world. *Subjectivist* means that the world as an unknown entity with the researcher tasked with constructing an impression of it. *Transactional* means that the truth is viewed as arising from the interaction of elements of some situation. Hence, in constructivism the researcher and the investigation are linked such that the findings of a study are created as the research proceeds.

For this study, the chosen epistemological stance is constructivism. The researcher was able to holistically study the participants’ constructed realities; by collecting data from recent CS graduates from Libyan institutions of higher learning and other stakeholders in the IT sector; the researcher used this information to construct the multiple realities that existed for those individuals at the time the information was collected.

THEORETICAL PERSPECTIVE

The theoretical perspective is the philosophical stance that informs the research methodology. For this research, critical theory was used.

Critical theory

Critical theory is a school of thought whose primary objective is the improvement of the human condition (Habermas, 1970). It focuses on general theoretical

problems and the investigation of specific concrete problems affecting social organizations.

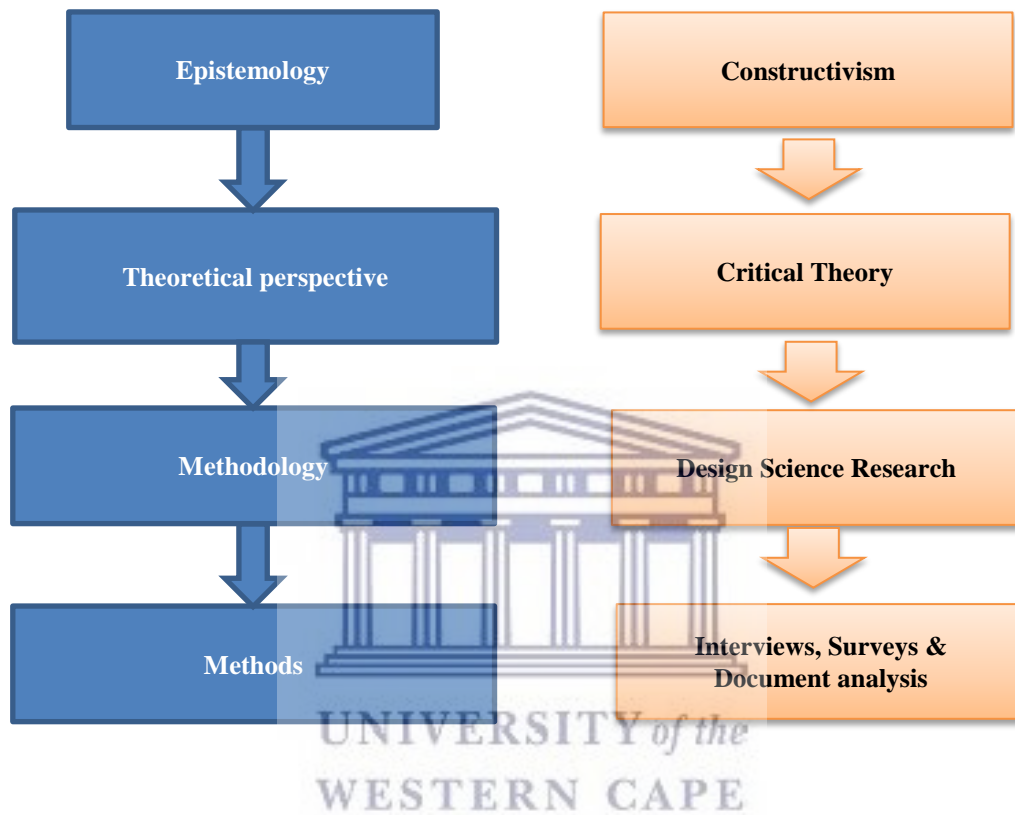


Figure 5: Methodology approach based on Crotty (1998)

Critical theory rejects the separation of knowledge and action and, value and inquiry by challenging the unity of scientific methods with respect to social affairs as illustrated in see Figure 5.

In social research and practice, critical theory is based on five fundamental assumptions:

1. the power to change the world belongs to the people
2. knowledge of the social world is value laden
3. reason and critique cannot be separated
4. an interconnection must always exist between theory and practice
5. critique and reason ought to be reflective in practice.

Habermas (1970) broadened the discourse on critical social theory to include strands of contemporary thoughts. His belief is that a rational critical approach is needed to guarantee that society maximises the benefits of the advancements in technology while minimising the disadvantages. To implement such a methodology, three types of knowledge interest are required: technical, practical, and emancipatory knowledge interests.

Table 4: The knowledge interests as defined by Habermas

KNOWLEDGE INTEREST	KNOWLEDGE PRODUCTS
Technical	Scientific Knowledge—Technology
Practical	Social Consciousness—Humanity
Emancipatory	Norms for Justice—Freedom

The technical knowledge interest revolves around the need for humans to predict and control the social and natural world. The practical knowledge interest revolves around the quest by humans for self-understanding whereas the emancipatory knowledge interest considers the freedom from mental and physical restrictions and social distortions.

METHODOLOGY

Methodology is the plan of action to be followed to conduct research. A methodology usually entails steps, each step requiring some method to collect data which must be analysed to give a result. In the field of information systems, CS and engineering, research often entails the development of an artefact. For such research Vaishnavi and Kuechler suggested a methodology called design science research (Vaishnavi & Kuechler, 2012).

Design science research

Research based design or Design Science Research (DSR) involves the generation of new knowledge by designing new and innovative artefacts whose use and performance can then be analysed to assess the performance of the stated artefacts (Vaishnavi & Kuechler, 2012). To use the DSR, a certain process needs to be followed as illustrated in Figure 6.

The general methodology of design science research

Design science research as a paradigm has been used in engineering and the sciences and has gained interest in the education sector as well. It is fundamentally a problem solving paradigm. It seeks innovations that define the ideas, principle and practices, that have technical capabilities, and products through which the analysis, design, development and implementation, management, and use of information systems and soft skills can be effectively and efficiently accomplished (Hevner, March, Park, & Ram, 2004).

The steps of the design science research process

Awareness of a problem: As awareness of a research problem can come from multiple sources. This may include a literature review, study reports, new developments in an industry or a shift in policy that results in challenges that need to be addressed. The output of the awareness of a problem phase is a research proposal.

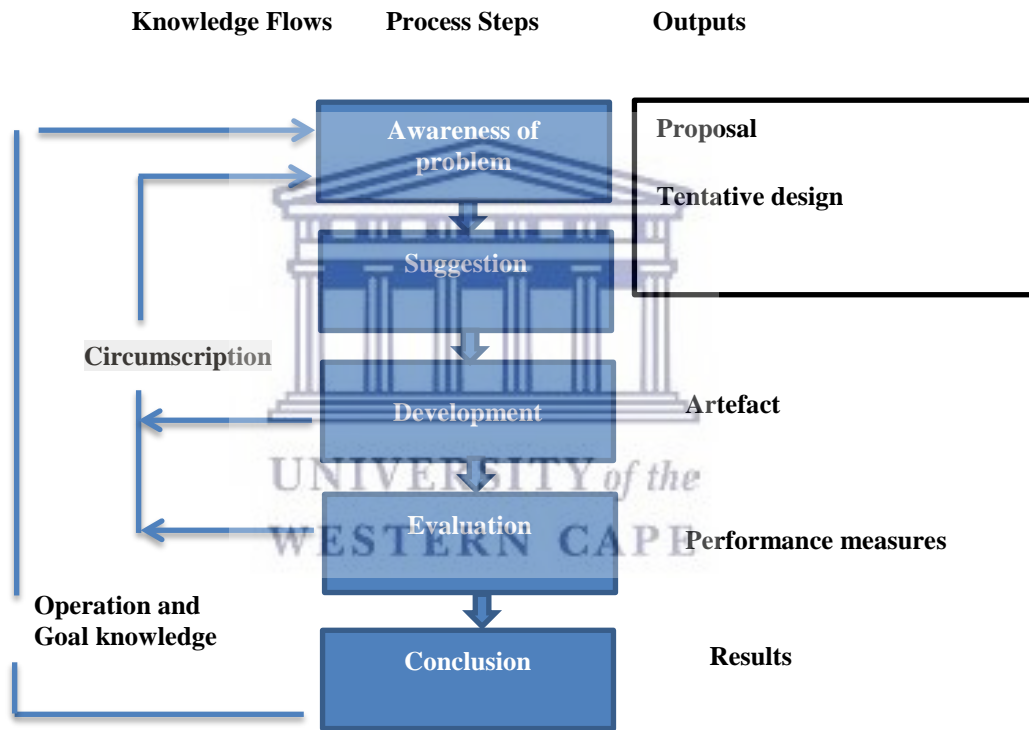


Figure 6: Design science research process model (DSR Cycle)

Suggestion: This phase links the proposal with a tentative design that tries to address the problem identified earlier. However, for the generation of good, achievable and practical suggestions, the research proposal should include a prototype—either a representation of the problem or an expected outcome, a survey, or interview study or document analysis. It provides a platform for

creativity when coming up with recommendations of how to improve existing elements or generating new ones.

Development: The development of the tentative design is implemented in this phase. The implementation technique is however dependent on the type and complexity of the artefact to be implemented e.g., an algorithm might focus on the generation of a proof of concept using existing structures whereas an expert system may embody new assumptions generated using high-level packages and tools.

Evaluation: Evaluation of the artefact is performed here with any deviation from the expected results being noted and comprehensively explained. This phase provides a platform to test hypotheses about the artefact.

Conclusion: This is the final phase of the research cycle characterised by results that are factual and repeatable. Additionally, this being the final phase, means that proper communication on the outcome of the research, its knowledge contribution to science and future developments and expectations from the research should be made.

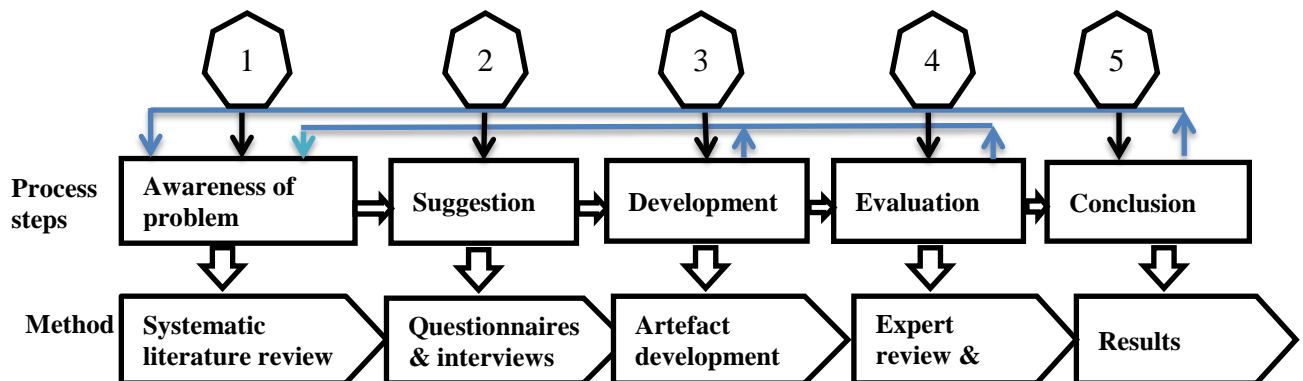


Figure 7: DSR process model adapted for this research

METHODS

As is indicated in Figure 7 the following methods were used during the development phase as well as the evaluation phase of the design science research methodology:

Systematic literature review

To become aware of the extent of the problem a literature review was done. The systematic procedure of reviewing documents, either printed or electronic for the purpose of obtaining data (Bowen, 2009) allows the researcher to become more aware of the information available about the problem.

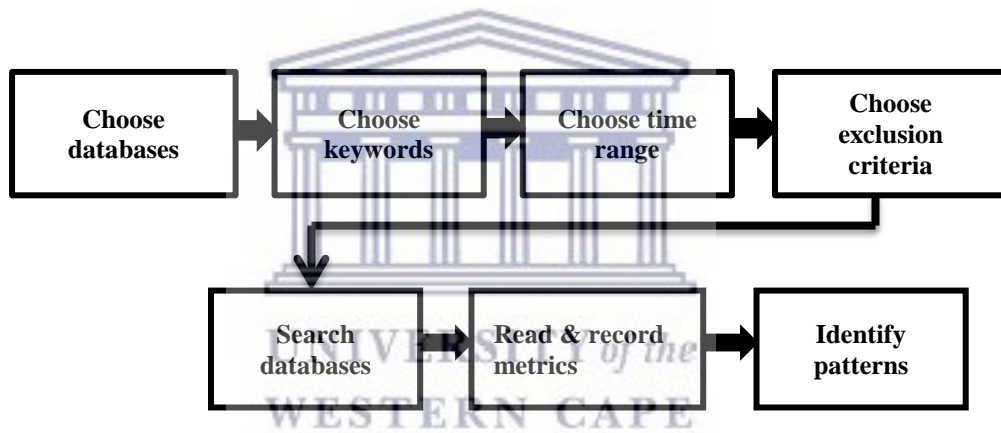


Figure 8: Systematic literature review

The documents reviewed are based on identified key words that enable the researcher to (relate and) identify research and information that has already been published and which relates to the research questions of this study as illustrated in Figure 8.

Questionnaire and interviews

Questionnaire

A questionnaire is a set of questions structured in a systematic manner that aids in the collection of data from respondents in a research setting (Kelley, Kate, &

al, 2003). Questionnaires may be administered via post, presented in a group or be self-administered and they include attitude scales, check lists, rating scales or projective techniques (Oppenheim & Abraham, 2000).

Interviews

In qualitative research studies, interviews are a key data collection method and they are useful where: highly personalised data needs to be collected; there is an opportunity to probe to acquire underlying factors relating to a given phenomenon or; where there is a limited number of respondents (Gill, Stewart, Treasure, & Chadwick, 2008; Denzin & Lincoln, 2000). Interviews aid in the complete understanding and analysis of research subjects and topics; are critical for discovery-oriented researches especially where the interviewer is only roughly certain of what they are looking for (Gill, Stewart, Treasure, & Chadwick, 2008).

There are three different types of interviews:

1. **Structured interview:** This is very rigid and follows a pre-determined structure, thus allowing for little if any scope of follow up questions (Gill, Stewart, Treasure, & Chadwick, 2008). Therefore, it is quick to administer and applicable where the number of respondents is large.
2. **Unstructured interview:** This allows for the collection of in-depth information (Gill, Stewart, Treasure, & Chadwick, 2008) by allowing the combination of both structure and flexibility in the data collection process.
3. **Semi-structured interview:** This is a cross between a structured and an unstructured interview, as it allows a researcher to define an area of exploration while permitting flexibility when it comes to pursuing ideas, in cases where a response is unsatisfactory (Gill, Stewart, Treasure, & Chadwick, 2008).

DATA EDITING, CODING AND ANALYSIS PROCEDURES

Data editing involves the process of assessing and adjusting data to ensure there is no omission, inconsistency or illegibility. When the researcher discovers irregularities in the collected data, they adjust the said data to ensure it is complete, readable and consistent. Data editing can be performed either in the field or in the office (Cooper & Schindler, 2014).

Data analysis is the process of ordering, structuring and deriving meaning from collected data. The process is time consuming, messy and at times ambiguous (Marshall & Rossman, 2016). As such, data analysis is the application of inductive and deductive logic to research interpretively. Data analysis can be either qualitative or quantitative (Marshall & Rossman, 2016). Qualitative data analysis is less standardised in its approach whereas quantitative data analysis follows a standard set of data analysis techniques. In this research both qualitative and quantitative data analysis are used.

ARTEFACT DEVELOPMENT

Artefacts can also be referred to as prototypes in research (Suchman, Lucy, Randall, & Jeanette, 2002). They are draft versions of products which aid in the exploration of ideas (Usability.gov, 2018). In this section, artefacts are referred to as prototypes. Prototypes show the overall design concepts of an idea and intentions behind certain features that a researcher wants to pursue in their studies. A prototype can range from paper drawings (low-fidelity), items that allow for inspection of basic features of the intended product to a fully functioning site (high-fidelity) (Walker, Takayama, & Landay, 2002).

EXPERT REVIEW AND TESTING

The usability of products is important for their practicality and uptake by the intended user. Hence, there is a need to review and test developed products to

ensure user experience is factored into the design. In the review and testing of products, there are ten rules that need to be followed according to Nielsen (1994). However, for the purposes of expert review and testing of the artefact in this research, only four rules are used: visibility of system status, aesthetic and minimalist design, help and documentation, and finally user control and freedom (Preece, Sharp, & Rogers, 2015).

The visibility of the system considers the ability of the artefact to give a real-time update of its status at any given time. This is applicable, for instance, when a user enters their credentials to log-into the system. How would they know whether the system is loading or that it has hanged?

The aesthetics and minimalist design focuses on the relevance of the information that is being presented on the page of the artefact (Preece, Sharp, & Rogers, 2015). For instance, does the log-in page into the artefact only contain information relevant to log-in details or is it unnecessarily filled with irrelevant information.

Help and documentation focuses on checking whether the intended user can, ideally, navigate through the artefact with minimal, if any, reference to the help and documentation steps.

Finally, the user control and freedom focuses on the freedom given to users to navigate and use resources in the artefact, such as undoing accidental actions, like the deletion of files.

Design of the research and data collection

The DSR methodology is applied as follows:

AWARENESS

Systematic literature review

As illustrated in Figure 9 the systematic review focused on the CS curriculum as taught in HTVIs in Libya. However, to understand the subject matter better and place it in the African continent, documents on CS in other African countries were also reviewed. For the systematic literature review the following were considered:

Databases: The literature contained in databases such as Scopus, Google Scholar and Research Gate were studied.

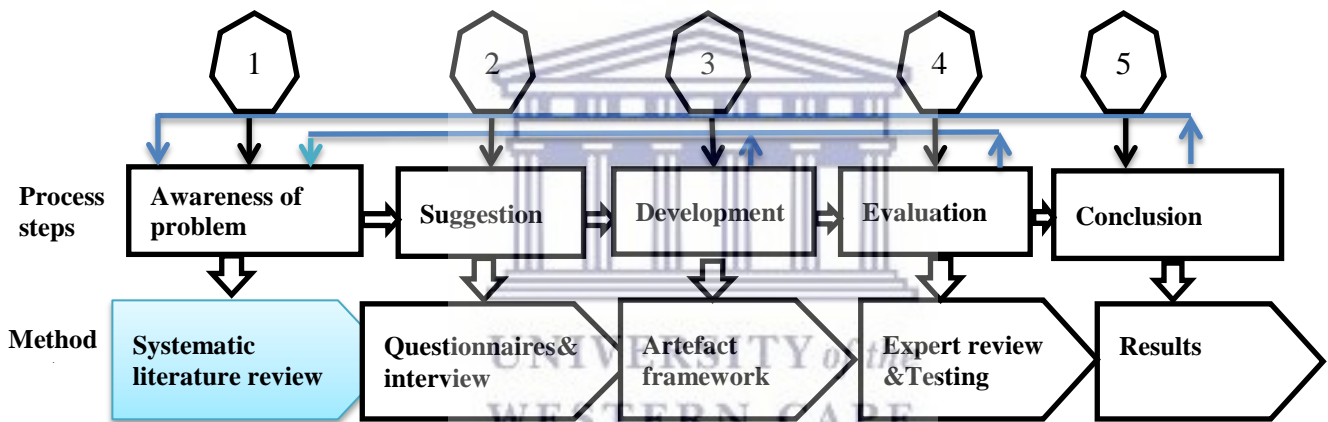


Figure 9: Step 1—Systematic literature review

Keywords: Literature around curriculum development, curriculum analysis, development and analysis of the CS courses in developing countries were identified. Keywords such as ICT, CS courses and Libya were used to select articles.

Exclusion Criteria: Literature on CS in developed countries as well as in schools was excluded.

Time Range: The availability of information about the Libyan education system and its resources are limited due to the political instability of Libya which started in 2011 (Nokut, 2017). This has led to a lack of consistent information about tertiary education. Thus, only articles that were published from 2010 onwards were considered, except for seminal works which may be from dates earlier than 2010.

The documents were read and common words across the documents were used to search for additional literature that was further reviewed. The list of references in each article was used to obtain more literature around the identified subject.

SUGGESTION

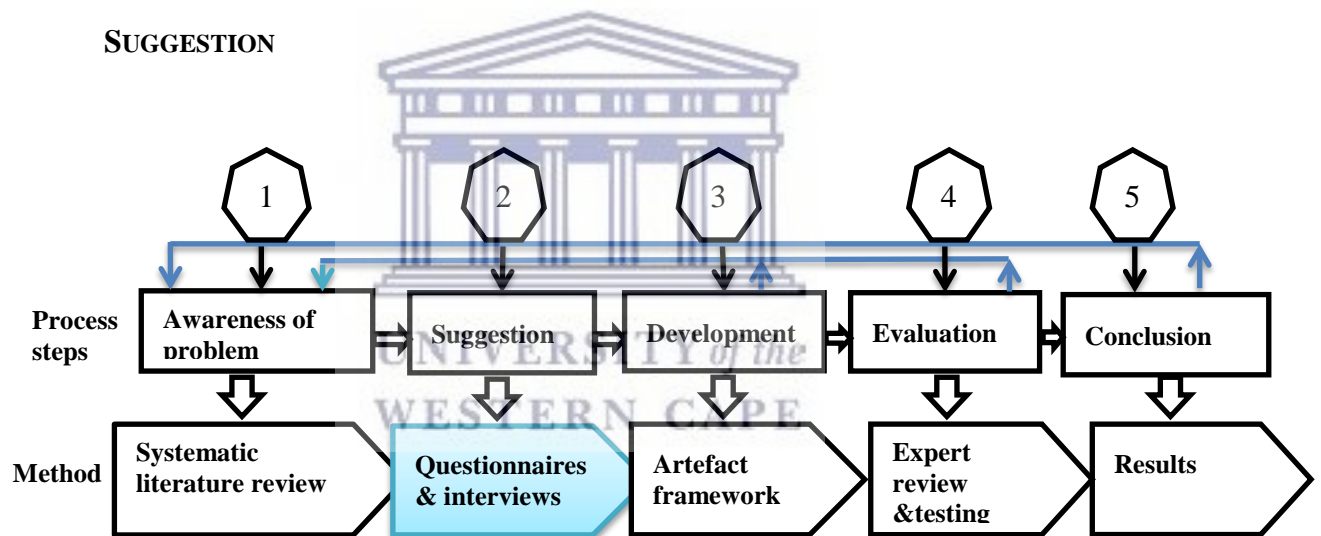


Figure 10: Step 2—Survey within the DSR process model

The result of the document analysis was fed into the “suggestion” and was used to compile a number of questionnaires which were applied in a cyclical manner. The first questionnaire was a pilot that allowed the researcher to refine the instrument.

The two subsequent questionnaires addressed different aspects of the problem. To get rich data on aspects not dealt with in the questionnaires, semi-structured interviews were conducted (see Figure 10).

Questionnaires

Three questionnaires were developed to elicit information on different aspects of the curricula of Libyan universities.

Questionnaire 1:

In April 2016, a questionnaire (see Appendix C) was compiled to elicit information about graduates from Libyan universities and how they coped with the skills they acquired from their institutions, in their workplace. The respondents were selected using the snowball sampling technique, that is, a nonprobability technique in which some study subjects are asked to recruit future subjects from among their acquaintances. Thus 4 lecturers at 3 Libyan institutions were initially identified and asked to send the Google Docs link of the questionnaire to colleagues who they knew had completed their degrees or diplomas at Libyan institutions, and who were working in the Information Communication sector locally as well as internationally. The digital questionnaire consisted of fourteen questions addressing possible attributes their workplace would require of a CS graduate. Fifty-two graduates responded to this questionnaire.

Some of the questions were open-ended thus allowing the participants to provide their own answers for general questions.

The responses to the questionnaire were analysed by compiling the information in an excel sheet and categorising the responses into groups based on the answers provided by the respondents. The quantitative data was then visualised using graphs and the open-ended questions were summarised and categorised in tables.

This allowed for easier interpretation and visualization of the results (see Appendix D).

Questionnaire 2:

To collect information about specific graduate attributes, a questionnaire was designed considering the suggested attributes of the following institutions: ACM IEEE, University of the Western Cape, University of Sydney, Victoria University and Computing Curricula in Sub-Saharan Africa, and these attributes were compared. The information displayed in the table was collected from these institutions' websites. The same method could not be used to collect data about graduate attributes at Libyan institutions, mainly because access to the institutions via the Internet was intermittent and online information about these institutions and their courses was sparse or totally lacking. Information about the graduate attributes of Libyan institutions was therefore collected from Libyan lecturers by designing a questionnaire in both English and Arabic (see Appendix F).

This questionnaire dealt with what the respondents considered to be important graduate attributes that all Libyan graduates should have acquired whilst at university. The questionnaire was sent via email to departments of CS, the meetings were conducted at four Libyan institutions that offer computing as a discipline and also with Libyan IT companies. A snowball technique was used.

Fifty-three responses were received, of these, forty were from lecturers, six from employees in the IT department of Oil Company and seven responses were from the employees of small IT companies. The questionnaire was administered between the months of April 2016 and June 2016.

Questionnaire 3:

The results of Questionnaire 2 and the attributes, as defined by some international universities, were used to create the third questionnaire. Google Docs was used to

design and deploy the questionnaire. It was sent to IT employees from different companies as well as lecturers at Libyan universities. Care was taken that these identified respondents had not taken part in the study previously.

Fifty-six responses were received: eight respondents worked as IT managers at different IT companies; one worked as an IT administrator; two were networking engineers at Oil Companies; one was a manager at Libyan Post Telecom and forty-four were lecturers at universities and institutions in Libya that offer the discipline Information Technology (see Appendix G). The questionnaire was administered between the months of June 2016 and September 2016.

Interviews

In this research, semi-structured interviews were conducted to ensure that the researcher conducted his interview in a structured way while still permitting the interviewees to pursue certain ideas that arose during the interviewing process. Interview schedules were used and questions that elicited most responses from the respondents were prioritised.

Additionally, the semi-structured interviews focused on the CS field and related industries and sought to find out whether the knowledge that CS graduates acquired while at school in Libyan institutions of higher learning had contributed to the skills that are required and are essential in the stated field.

Interviews via Skype were conducted with a total of 5 participants and 30 minutes were allocated for each interview. The interviews were conducted in English, but since the home language of most of the participants was Arabic, there were instances where aspects had to be clarified to ensure the researcher and the interviewee understood each other. Fortunately, the researcher is also Libyan and where the interviewee required further clarification, the researcher engaged with

them in Arabic and translated the interaction into English for processing purposes (see Appendix J).

Qualitative analysis was used on the data that was obtained from the interviews and on data from the open-ended questions in the questionnaire, whereas quantitative analysis was used on data obtained from the rest of the questionnaire.

DEVELOPMENT

Artefact

Low-fidelity prototyping using paper and pencil was used to design the initial framework. This was done because such prototypes are easy to produce and change and can express the idea of the design. This initial design of the prototype was discussed with two experts (one with a PhD and one with an MSc in CS, working at the University of the Western Cape) to get their comments and feedback.

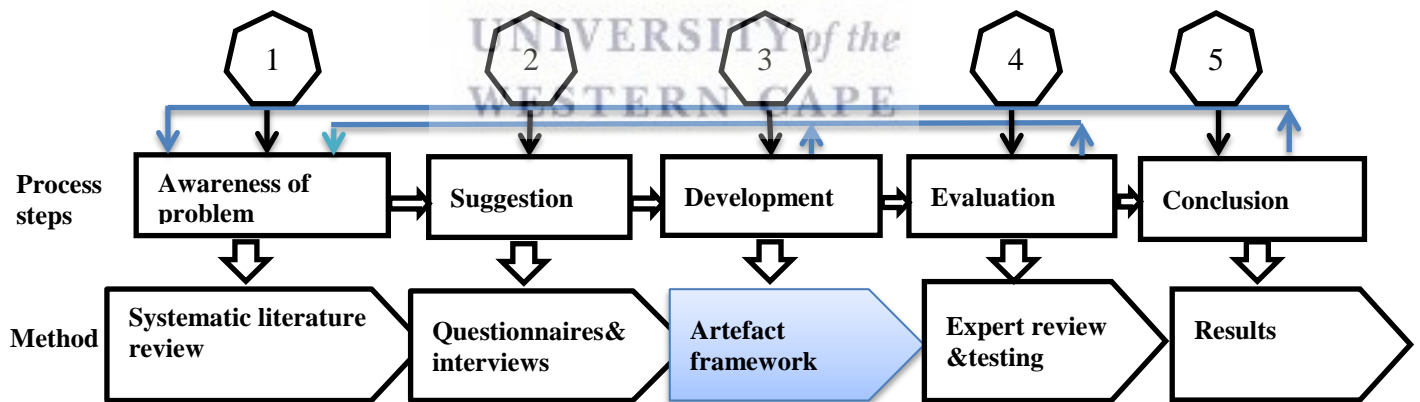


Figure 11: Step 3- Artefact within the DSR process model

When it was felt that the paper-form prototype was satisfactory, it was translated into a high-fidelity framework using the online *Fluid UI*. *Fluid UI* is a browser-

based prototyping tool developed by *Fluid Software*¹. This prototype was again evaluated by the same two experts to check if their comments and feedback were implemented correctly. The prototype was then refined before the artefact was developed (see Figure 11).

Software used for the front- and back-end of the artefact

*Bootstrap*², a framework developed by Mark Otto and Jacob Thornton from *Twitter*, was used for the development of the front-end of the artefact. The framework, originally named *Twitter Blueprint*, is free and currently the most used framework on *Github*³. *HTML*⁴, *CSS*⁵-based design templates, *PHP*⁶ and additional *JavaScript* extensions allowed for the design and development of a responsive website and the online application (Ouellette, 2017). In addition, the *PHP* scripting language was used for the server side scripting. *MySQL*⁷, an open-source relational database was used to store information about users, courses and other related information.



¹ <https://www.fluidui.com/best-software-design-tool>

² <https://getbootstrap.com/>

³ <https://github.com/>

⁴ <https://www.w3schools.com/html/>

⁵ <https://www.w3schools.com/css/>

⁶ <https://www.php.net/>

⁷ <https://www.mysql.com/>

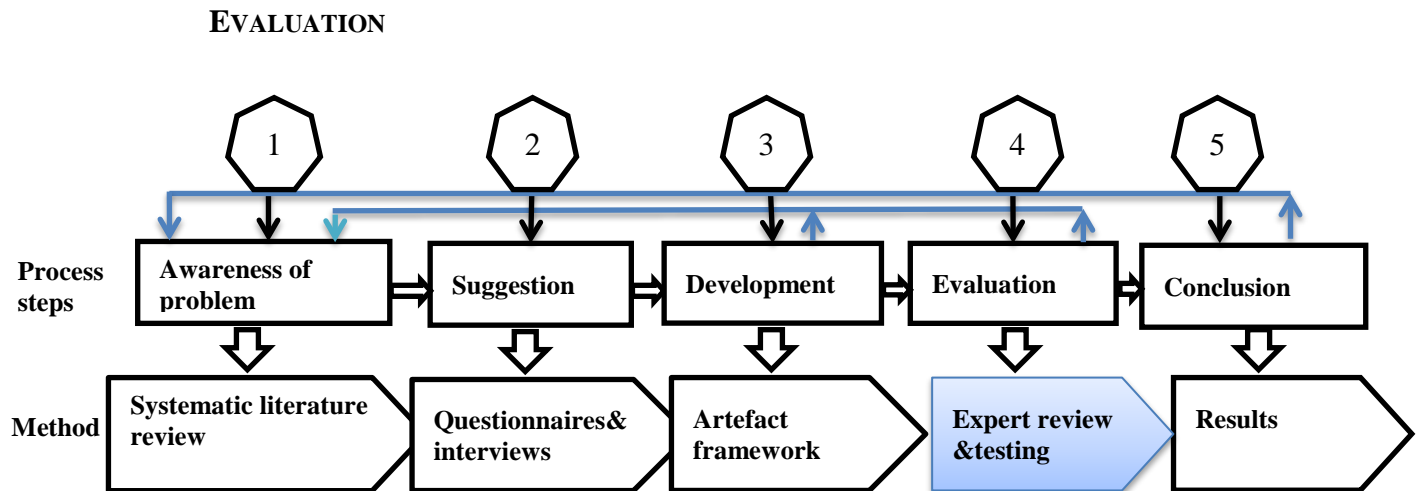


Figure 12: Step 4—Expert review within the DSR process model

Expert review

As can be seen from Figure 12 Step Four entails the evaluation of the prototype. Five experts reviewed and tested the final prototype as proof of concept. According to Preece *et al.*, five experts will be able to identify approximately 75% of usability problems (see Figure 13) (Preece, Sharp, & Rogers, 2015, p. 409).

The questionnaire was designed with the following usability criteria (or heuristics) in mind:

- Visibility of system status;
- Aesthetic and minimalist design;
- Help and documentation and;
- User control and freedom.

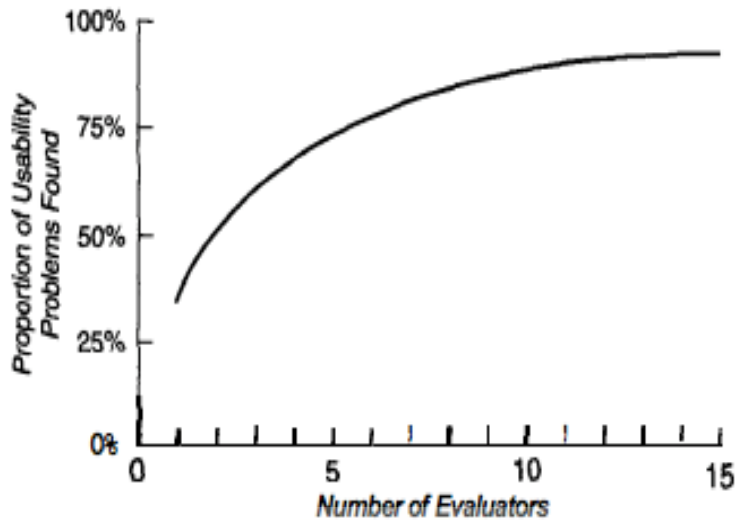


Figure 13: The curve depicts the ratio of problems within an interface identified by a heuristic evaluation using a range of numbers of evaluators (Preece, Sharp, & Rogers, 2015, p. 409)

The experts chosen for the evaluation were CS professionals, all of whom had qualified with a PhD. One of the 5 respondents qualified at a university in Libya, two at higher institutions in Libya (HTVI) and two were from the University of Western Cape.

A scenario was sketched and tasks were designed for the Administrator, the Lecturer and the Guest. The experts were asked to consider the scenario and the chosen heuristics when completing the tasks. After completion of the tasks the experts were asked to complete a survey and rate the question from 1 to 5 on a Likert scale, where 1 indicated “*Strongly disagree*” and 5 “*Strongly agree*”. An online survey—using Google Forms—was designed and used for this evaluation, and data was collected during November 2018 (See Appendix I).

CONCLUSION

The conclusion is the last step of the DSR process and is a summary of the results of the project and this will be discussed in Chapter 4.

Summary

In this chapter, the research approaches as well as the research design were described. Also, the research instruments, research methodology of this research effort were presented. In the next chapter the results will be presented.



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Introduction

In the previous chapter, the research approaches as well as the research design were discussed. This chapter focuses on the results of each step of the DSR research methodology.

Results according to the steps of the DSR methodology

STEP 1 AWARENESS OF THE PROBLEM

Document analysis

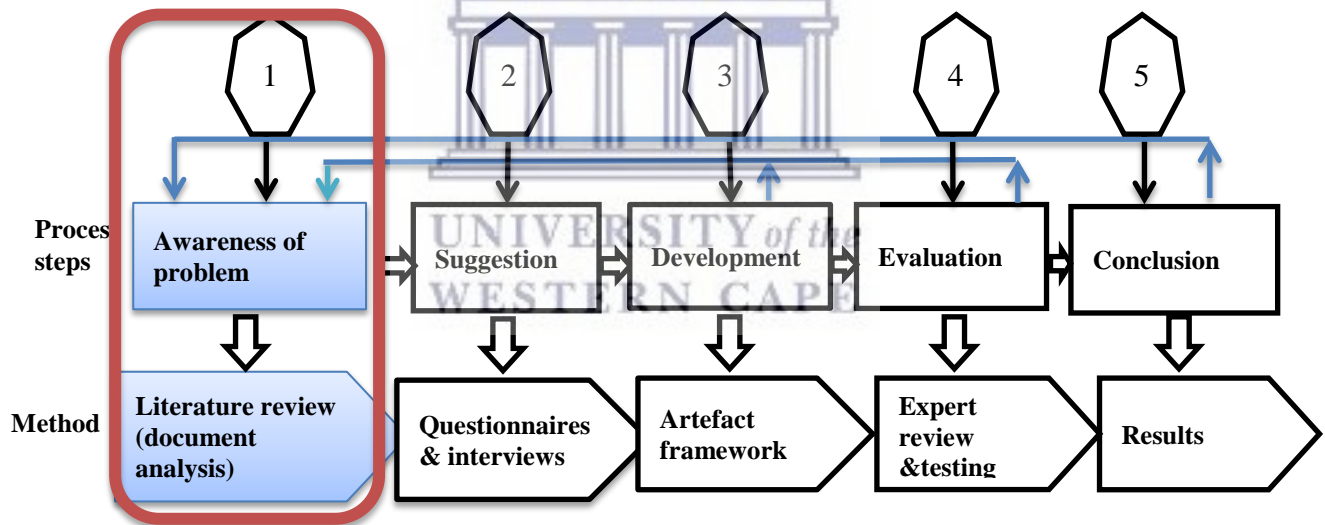


Figure 14: Document result within the DSR process model

To analyse literature around curriculum development, curriculum analysis, development and analysis of the CS courses in developing countries, keywords were used to select articles (see Figure 14) and (see Table 5).

From the document_analysis, it was found that the curricula of CS programs in most institutions of higher learning in Libya do not align with recommendations outlined by the ACM.

Table 5: Document analysis and systematic literature review results of the Libyan education system

KEYWORDS	INFORMATION RETRIEVED	ARTICLES USED
Information communication technology	Since the Libyan civil war that started in 2011, many projects were shelved. A few improvements to ICT resources have been implemented since the revolution.	(Shade, O, & Samuel , 2012) (Rouse, TechTarget, 2015) (Freedom House, 2016)
Digital divide	Because Libya had almost no debt in 2010, it was able to establish an exceptional Information and Communications Technology (ICT) communication infrastructure. The country recorded a GDP per capita of 5449.03 US dollars with a growth rate of - 8.10% against a global average of 3.1%. ICTs or digital technology continue to boost economic growth in many countries by expanding opportunities for individuals, communities and countries in improving service delivery. However, it ought to be noted that the average impact of these technologies has fallen short of expectation because it is unevenly distributed. According to Freedom House, an international independent watchdog organization which is committed to determine the use of the Internet and how free and democratic it is, Libya currently (2017) has an Internet penetration rate of 20.3 % (Freedomhouse, 2017).	(Elzawi, Kenan, Wade, & Pislaru, 2013) (UNDP, 2016) (World Development Report 2016: Digital Dividends, 2016) (Freedomhouse, 2017)
Higher technical and vocational institutions	The focus of the higher technical and vocational institutions (HTVI) is on Electrical Engineering, Mechanical Engineering as well as Finance. Whereas Computer Studies, Industrial Technology, Social Work, Medical Technology and Civil Aviation. In HTVIs, the trained individual is awarded a college diploma whereas in university, the individual is awarded an undergraduate or postgraduate certificate depending on their level of qualification.	(Iwona Miliszewska , 2010). (Tamtam, Gallagher, Olabi, & Naher, 2011) (Tamtam, Gallagher, Olabi, & Naher, 2011) (Rhema, Miliszewska, & Sztendur, 2013)
Computer skills	The level of basic computer related knowledge is even low in Higher Technical and Vocational Institutions (HTVI) other than in the Computer Science Department.	(Rhema, Miliszewska, & Sztendur, 2013) (Leonard, 2018)

KEYWORDS	INFORMATION RETRIEVED	ARTICLES USED
	The majority of educators and students in Libya are either computer illiterate or have had an exposure to computers and thus have limited computer ability.	
Computer related Curricula	In an effort to standardise the reform of programs and curricula, there has been a shift from the traditional way of developing and approving curricula to a much more centralized system of reforming programs and curricula for higher institutions.	(Othman, Kashadah, Gosbi, & Khoja, 2012) (Directory, 2015).
Developing country	Libya's GDP grew by approximately 2% from -10.1% GDP growth rate in 2015 to -8.1% in 2016. This trend is expected to continue as the country resumes oil production following the civil unrest of 2011. HDI is a measure of assessing human development in terms of long, healthy life, decent standard of living and access to knowledge. Libya is ranked as a developing country according to the World Bank.	(Economics, 2016) (The World Bank, 2017)
Graduate attributes	Libyans employers are looking for graduates who are knowledgeable, have good interpersonal and communication skills, can critically and analytically access situations, are able to work in a team setting and most importantly, graduates who are willing to learn.	(Simon C & Barrie, 2004) (Impes, Othman, Wilson, & Pislaru, 2014).

The curricula of the ACM IEEE, University of the Western Cape, University of Sydney, Victoria University and Computing Curricula in Sub-Saharan Africa (Rai, Rodrigues, Venter, Mills, Suleman, & Edumadze, 2013) were compared to see how these interpret the graduate attributes and knowledge fields of CS (see Table 6).

According to this information from the document analysis, CS programs ought to capture the eleven graduate skills as outlined by the ACM curriculum. However, most CS courses in Libya fail to provide training on one or more of these skills for its graduates. The courses do not equip students for life-long learning. Most

students have poor problem solving skills and there is little focus on enhancing CS course modules in order to equip students with good communication skills.

Table 6: Comparing the graduate attributes of international universities with that of suggested by the ACM

ACM ASSOCIATION FOR COMPUTING MACHINERY	UNIVERSITY OF THE WESTERN CAPE, SOUTH AFRICA	SYDNEY UNIVERSITY, AUSTRALIA	VICTORIA UNIVERSITY, WELLINGTON, NEW ZEALAND	COMPUTING CURRICULA IN SUB-SAHARAN AFRICA
(Roach & Sahami, 2013)	(Graduate Attributes, 2014)	(The University of Sydney School of Education and Social Work, 2018)	(School Computer Science, 2017)	(Rai, Rodrigues, Venter, Mills, Suleman, & Edumadze, 2013)
Technical understanding of Computer Science	Technical ability and computer literacy		Be able to use a range of programming languages and tools to develop computer	
Familiarity with common themes and principles		Apply research principles and methods for gathering and analysing data/information relevant to major fields of study	Be equipped with a range of fundamental principles of Computer	
Appreciation of the interplay between theory and practice				Theory, Design, Modelling
System level perspective	Able to follow and construct logical argument			
Problem solving skills		Identify, define and analyses problems and recommended innovative solutions.		Problem solving Team working
Project experience		Personal and Intellectual autonomy		Projects, Field work, Internship, Innovation, Commercialisation, Entrepreneurship

ACM ASSOCIATION FOR COMPUTING MACHINERY (Roach & Sahami, 2013)	UNIVERSITY OF THE WESTERN CAPE, SOUTH AFRICA (Graduate Attributes, 2014)	SYDNEY UNIVERSITY, AUSTRALIA (The University of Sydney School of Education and Social Work, 2018)	VICTORIA UNIVERSITY, WELLINGTON, NEW ZEALAND (School Computer Science, 2017)	COMPUTING CURRICULA IN SUB-SAHARAN AFRICA (Rai, Rodrigues, Venter, Mills, Suleman, & Edumadze, 2013)
Commitment to Lifelong learning	Interest in ideas and desire to continue learning	Research and Inquiry	Be able to understand, design, and analyses precise specifications of algorithms, procedures, and interaction behaviour	
Commitment to professional responsibility	Appreciation of different cultural contexts	Ethical, Social and Professional Understanding		Community outreach, Ethics, E-waste, Carbon footprint, Health
Communication and organizational skills	Communication skills	Communication skills	Have experience of working in teams to build software systems	Communication skills, Management and organisation, Structure, Governance
Awareness of the broad applicability of computing	Ability to find and access information	Use a range of searching tools (such as catalogues and databases) effectively and efficiently to find information.		
Appreciation of domain –specific knowledge		Graduates of the Faculty of Science will recognise and value communication as a tool for negotiating and creating new understanding, interacting with others, and furthering their own learning.		

Soft skills often are not considered important and therefore little is done to prepare students for team work and the workplace.

STEP 2 SUGGESTION

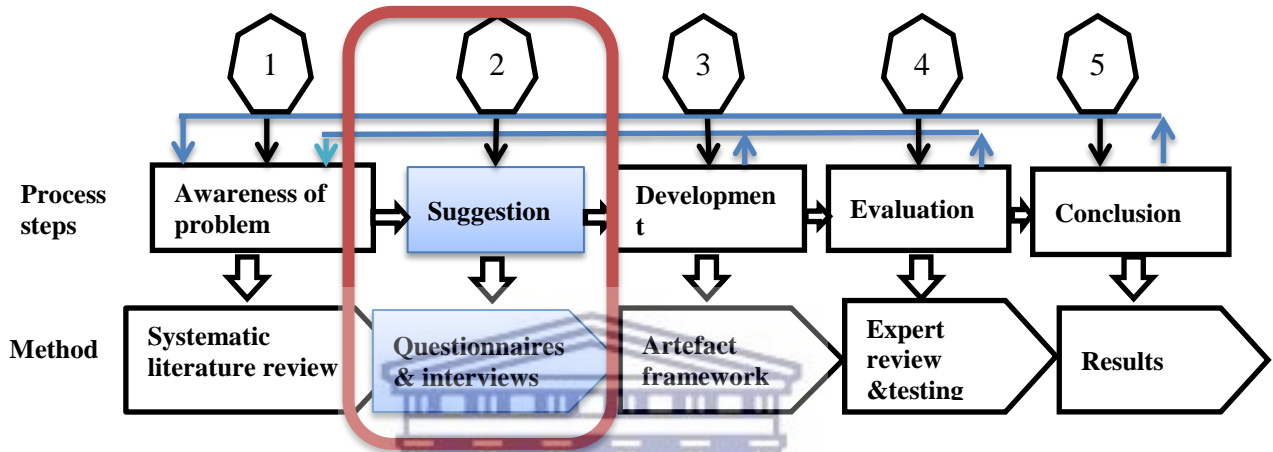


Figure 15: Survey result within the DSR process model

Questionnaire results

Questionnaire 1

The results of Step 2 (see Figure 15) entailed the analysis of questionnaires and interviews. Eighteen of the 52 respondents of the questionnaire qualified at universities in Tripoli: eight studied at institutions located in the city of Zawiya, seven in Tarhona, six in Bani Waled, four in Misrata, and three in Benghazi. Five were from institutions located in other towns. Thirty-four respondents received tuition in both Arabic and English, fifteen did it in Arabic alone and the rest received it exclusively in English. Twenty-seven respondents worked as technical computer engineers, eighteen worked as associate computer engineers, one was a senior computer engineer and the rest did not specify their profession. Seventeen of the respondents hold higher diploma qualification; fifteen have bachelor's degrees; fourteen have both a higher diploma and a bachelor degree; two have a bachelor and a master's degree, as is the case for those who hold a higher diploma,

bachelor and master's degree (see Figure 16). Two specified that they have a master's degree but did not specify what other qualification they have.

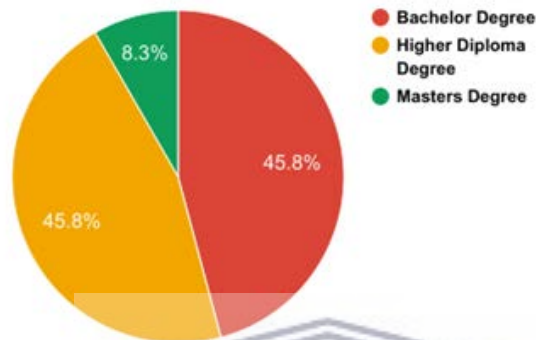


Figure 16: The qualifications of the respondents of the pilot questionnaire

The first section of the on-line survey collected descriptive statistics about the backgrounds of the respondents. Most of the respondents were still new in their profession with three still in their first year of work, 20 in their second year of work and 22 in their third year of work since their qualification. Only seven had worked for five or more years. The rest of the questionnaire focused on the graduate attributes as is suggested by the ACM. In a question that deals with how they understand certain concepts, only nine understood the concept of *abstraction*; sixteen understood the concepts of complexity and security; seventeen understood the concept of *evolutionary change*; twenty-seven understood the concept of *resource sharing* and; only eleven understood *concurrency*. In response to the question “Do you feel that the theory that you have learnt during your studies prepared you for the practical requirements of your workplace?” twenty five rated it as 2 and sixteen rated it as 1 on the Likert

scale (1 means “Strongly disagree” and 5 “Strongly agree”), indicating that their studies did not prepare them well enough for the workplace (see Figure 17).

When asked whether their qualification prepared them to think at multiple levels of abstraction and detail, 76% felt it did not. Similarly, 65% of the respondents felt that their communication skills in explaining computer solutions to others were poor. Only 21% of the respondents indicated that they were involved in at least one substantial programming project during their studies. Even though only 40% of the respondents indicated that they read books or articles about computing, 62% felt that they were up to date with the latest developments in computing. Most (82%) of the respondents stated that they had neither attended nor participated in any recent computing conference, competition or course, with only 11% having given a presentation on technical problems and their solutions to a larger audience. Additionally, 46% of the respondents stated that they have personal web-pages or blogs. Just fewer than 10% of the respondents have used a high performance computer cluster at their workplace or have attended a course that dealt with the social, legal or ethical aspect of the discipline of computing; with only 17% having ever consulted an expert in a domain outside their personal area of expertise (see Appendix D).

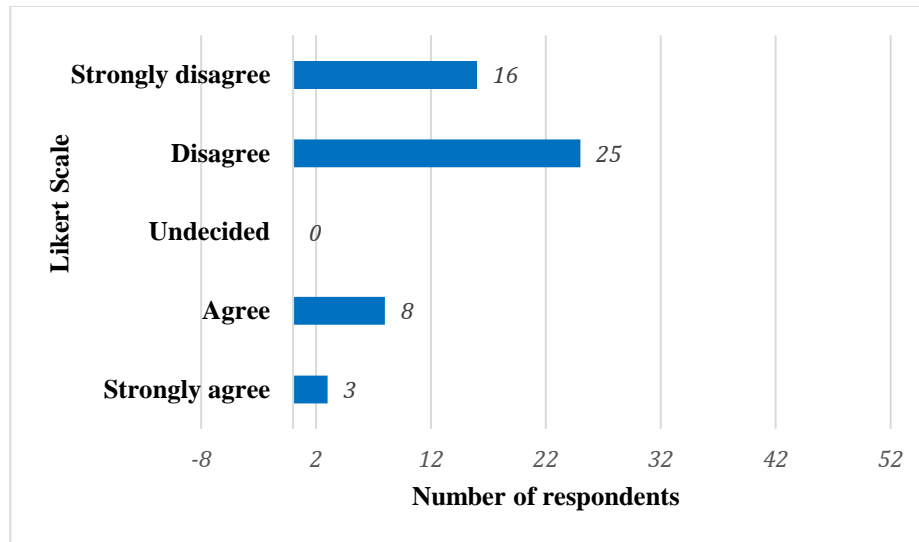


Figure 17: The theory learnt during university studies prepared the respondents for the practical requirements of their workplace

Questionnaire 2

The data was collected using an Arabic language questionnaire; the results were then then translated into English (see Appendix F). The research compares these Libyan graduate attributes skills with skills at other universities and the curricula suggested for Sub-Saharan Africa (see Table 6). These results show the most important graduate attributes skills, and these were used to design Questionnaire 3.

Questionnaire 3

The participants of this round are Computer Scientists who either qualified with a PhD or a Master's Degree (see Figure 18). Most have worked between 7 and 12 years at their companies or at the university. The questionnaire was administered between the months of February 2017 and March 2017 (see Appendix H). The participants were chosen based on their availability at the time of data collection.

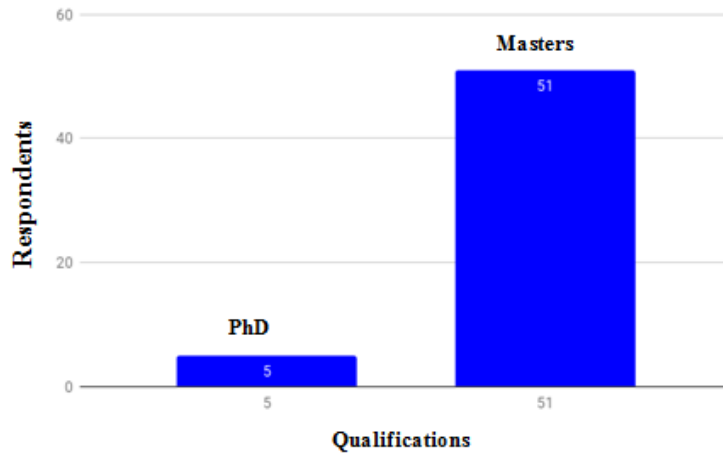


Figure 18: Qualification of respondents

The first section of the on-line survey collected descriptive statistics about the backgrounds of the 56 respondents. The rest of the questionnaire focused on the graduate attribute skills as defined by the ACM, IEEE, University of the Western Cape, University of Sydney, Victoria University and Computing Curricula in Sub-Saharan Africa and the responses from the previous questionnaire. The questionnaire asked the participants to rate the question from 1 to 10 on the Likert scale, where 1 indicated that it is not important and 10 that it is important.

In a question that deals with the application of the respondent's technical knowledge compared to their theoretical knowledge, most of the respondents 96.4% felt that the theoretical knowledge concept is important and only (3.6%) felt that it is not important.

When asked about how important it is to logically analyse a problem, most of the respondents felt that is important and only (8.9%) felt is not important. Many of the respondents 91.1% indicated that it is important to act ethically.

With regard to (acting ethically and) being professionally responsible 96.4% felt that it is important, whereas the others (4.6%) answered it is not important

When asked about communicating well with peers and seniors, some of the respondents (11.8%) felt is not important. While the others 88.4% felt it is important.

To the question about being able to work successfully as a member of a team, most of respondents 90.3% agreed that it is important whereas the others did not provided any answers (see Figure 19).

In terms of the management of a project most of the respondents, 89.2% said that it is important, whereas only (10.8%) indicated that is not important.

When asked about knowing how to manage ambiguity and complexity in assigned tasks, some of the respondents 67.2% indicated that it is important and only (9.4%) indicated that it is not important, whereas the others (24.3%) did not provided any answers.

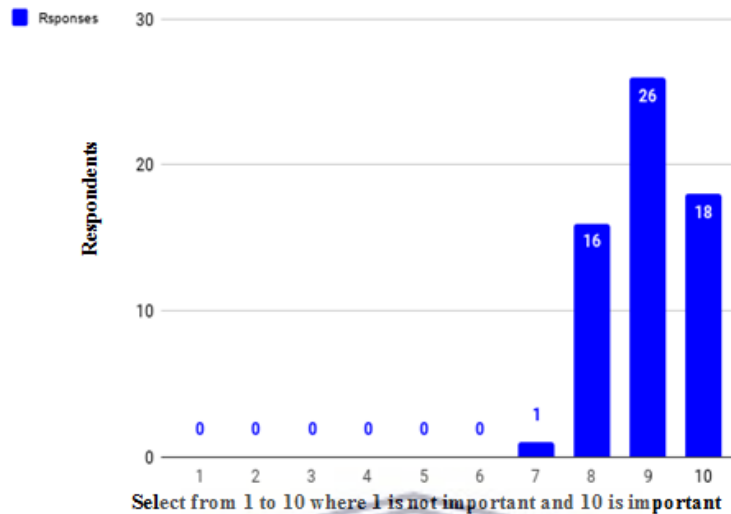


Figure 19: Work successfully as a member of a team

All of the respondents indicated that it is important to be able to program and that it is important to have the necessary programming skills.

When asked whether it was important for graduates to be prepared to learn throughout their careers in order to be at the cutting edge of technology, most of respondents (98.2%) agreed while a minority (1.8%) said it was not important.

In terms of the assertion that graduates must have a critical attitude towards knowledge, (96.4%) said it is important whereas (3.6%) said that it is not important.

Most of respondents (94.5%) indicated that it was important for graduates to have integrity and to be honest whereas (5.5%) of the respondents said it is not important.

Finally, when asked about whether graduates must have an appreciation for business and its application, most (87.4 %) of the respondents indicated that it was important and the rest of them (12.6%) indicated that it was not important (see Appendix I).

From the feedback of the industrialists and lecturers it can be seen that the following graduate attributes and skills are viewed as important:

- Value theoretical knowledge concepts
- Be able to logically analyse a problem
- Act ethically and be professionally responsible
- Communicate well with peers and seniors
- Work successfully as a member of a team
- Be able to manage a project
- Be able to manage ambiguity and complexity in assigned tasks
- Have the necessary programming skills
- Learn throughout their careers in order to be at the cutting edge of technology
- Have a critical attitude towards knowledge
- Have integrity and be honest

Interview results

Five Libyans, all working in the IT industry, were interviewed during the exploratory study. All of the interviewees were male although some females were approached but declined to participate. The females indicated that they preferred not to participate in this study, probably because of the Islamic traditions and customs. Creswell (2008) indicates that qualitative research does not require large numbers of participants since personal contact is required. Semi-structured interviews can provide the researcher with rich data (Creswell, 2008).

Three of the participants indicated that they chose their career because of it being related to their field of interest. Most of the participants indicated that they are responsible for the installation of software and maintaining the company's networks. When asked what type of qualification an employee in their company should have to be successful, two indicated that a Bachelor's degree would be enough whereas two indicated that a Master's degree would be better. Only one of the five answered that a higher diploma in software engineering would be optimal for his company.

When asked what the skills were that they acquired whilst at university and which they felt stood them in good stead in their positions, most of them answered that it was basic software programming skills. When probed further they indicated that it was the ability to use web applications, java script and multi-media. In addition, one added that English is very important, whereas another added that solving mathematical problems is also important. All of them indicated that they acquired communication skills (working as a team) at their place of employment. Four added that they have acquired the skill to solve networking problems and five that they are now able to deal with different operating systems such as iOS, Linux and UNIX.

When asked which courses should be added to the curricula of their institutions, most felt that they would have liked to learn more programming languages and to have been introduced to a variety of operating systems. Most of the participants, when asked how they think their college/university education could address these skills more effectively, said that the universities should focus on network problem solving skills and Graphical User Interface courses that would allow them to design websites. Two felt that they needed more training in the maintenance of hardware and one said that the university should focus on web programming skills. In addition, most of them felt that technical skills were more applicable in

their workplace than theory. All of the participants agreed that the university CS curricula should be up to date with technological developments in order to align it with international standards.

When asked what graduate attributes had contributed most to their accomplishments in their current company, one participant said that his ability to solve software problems and to work with a team effectively. Most of the participants were members of a team for some aspects of their work and felt that it was an important graduate skill.

Table 7: Responses to probes about graduate attributes

RESEARCH QUESTIONS	COMMENTS FROM INTERVIEWEES
What graduate attributes should be acquired by Computer Science students?	Most of them answered that it was basic software programming skills such as the ability to use web applications, java script and multimedia. In addition, one added that English is very important, whereas another added solving mathematical problems
What attributes does the workplace require from Libyan graduates?	Most of the participants were members of a team for some aspect of their work and felt that it was an important graduate skill to be able to contribute to the team effort
How does the curriculum of Libya align with the curricula from other countries and the ACM/IEEE?	Most of the respondents felt that the government and the ministry of higher education are responsible for curriculum development but should keep international standards in mind. All of the participants agreed that the university CS curricula should incorporate technological changes to keep up to date.
What factors would contribute to the development of specific graduate attributes?	Teaching staff members should furthermore belong to research units that are affiliated to international bodies. It would make it easier for them to keep up to date with revised curricula. Industry could contribute to the development of student skills by funding internships and forming partnerships with the institutions

Some felt that in order to deal with conflict, it is important to be patient and be prepared to listen and learn. Another felt that if they could not deal with conflict they would ask their employer to intervene. When asked how they handled situations where their communication failed them, some indicated that they

revised their opinion and tried to be more assertive by calling a meeting to solve the misunderstanding, more detail can be seen in Appendix H.

STEP 3 DEVELOPMENT

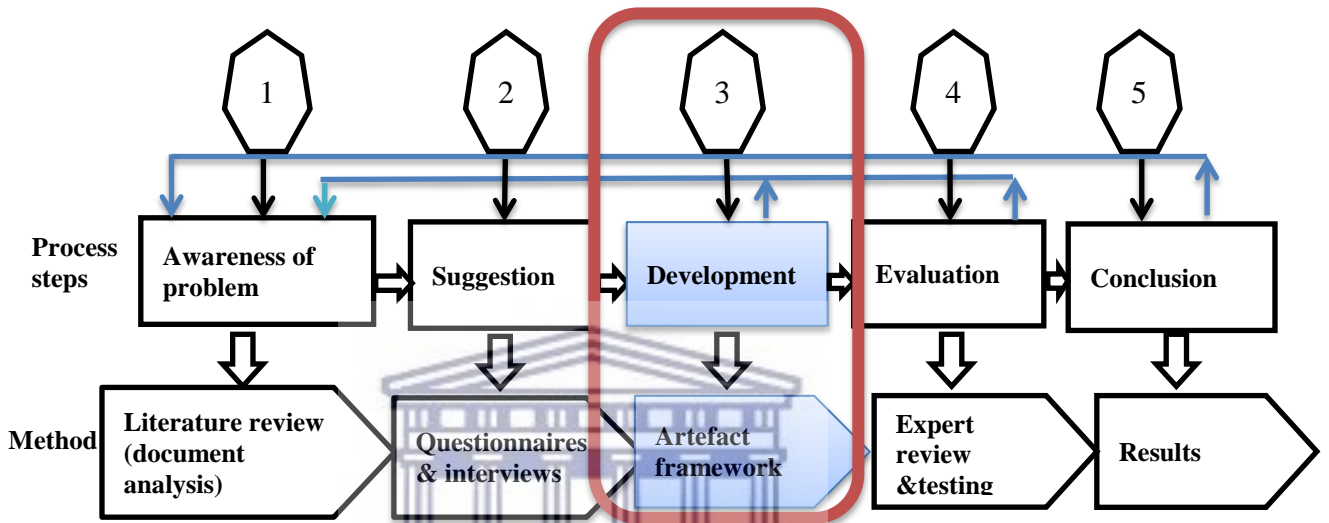


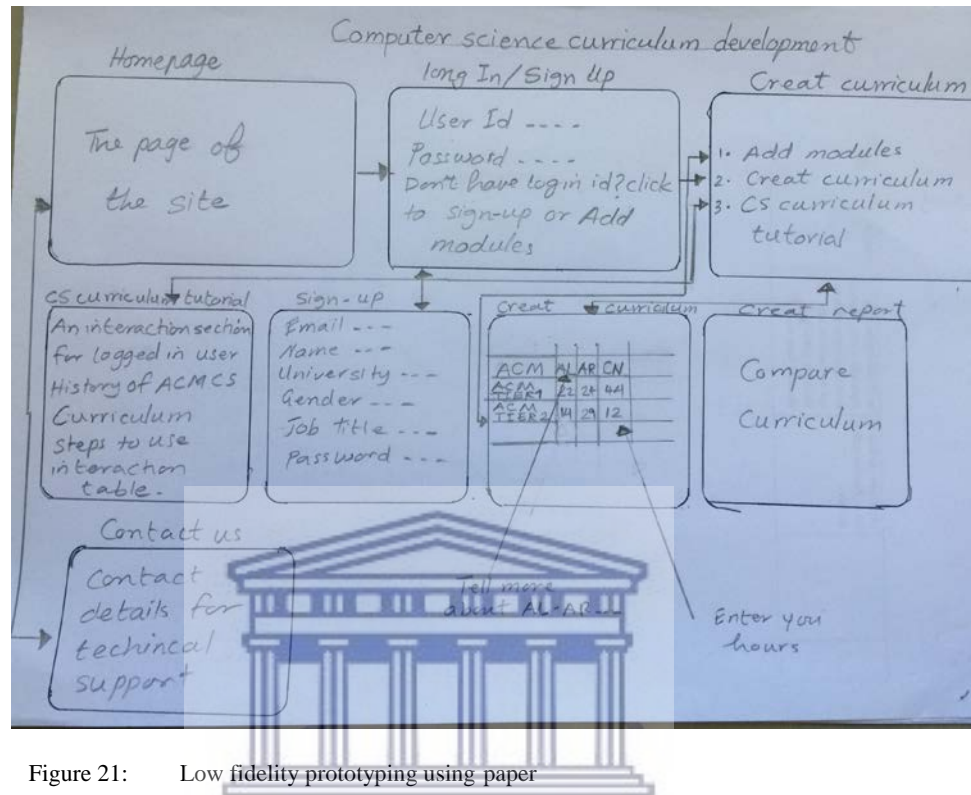
Figure 20: Artefact framework within DSR proses

Artefact framework

For Step 3 of the DSR methodology a prototype was developed (see Figure 20).

Low-fidelity prototype

Low fidelity prototyping using paper and a pencil was used to design the initial framework as is indicated in Figure 21. This was done because such prototypes are easy to produce and change and can express the idea of the design. When it was felt that the paper-form prototype was satisfactory, it was translated into a high-fidelity framework using the online *Fluid UI*.



High-fidelity prototype

Fluid UI is a browser-based prototyping tool developed by *Fluid Software*. The experts pointed out challenges with accessibility and recommended that users needed to be notified that the email has been sent to their address. To some certain extent, the experts agreed that the system had the important functions necessary and helped with the needs of users. In terms of feedback, the experts said that the speed at which challenges were responded to was favourable. The experts raised some concerns with understanding some of the functions but overall they concluded that it was logical.

Proof of concept

The initial response of the experts was that the high-fidelity prototype was easy to navigate. Experts said that the prototype allowed users to complete tasks

satisfactorily and guided effective problem solving. The design was also viewed as standardised and experts cited that the feedback would be satisfactory if the system information was regularly updated.

From the responses of the experts it was decided that three roles needed to be defined within the proof of concept system: the Administrator, the Lecturer and the Guest role.

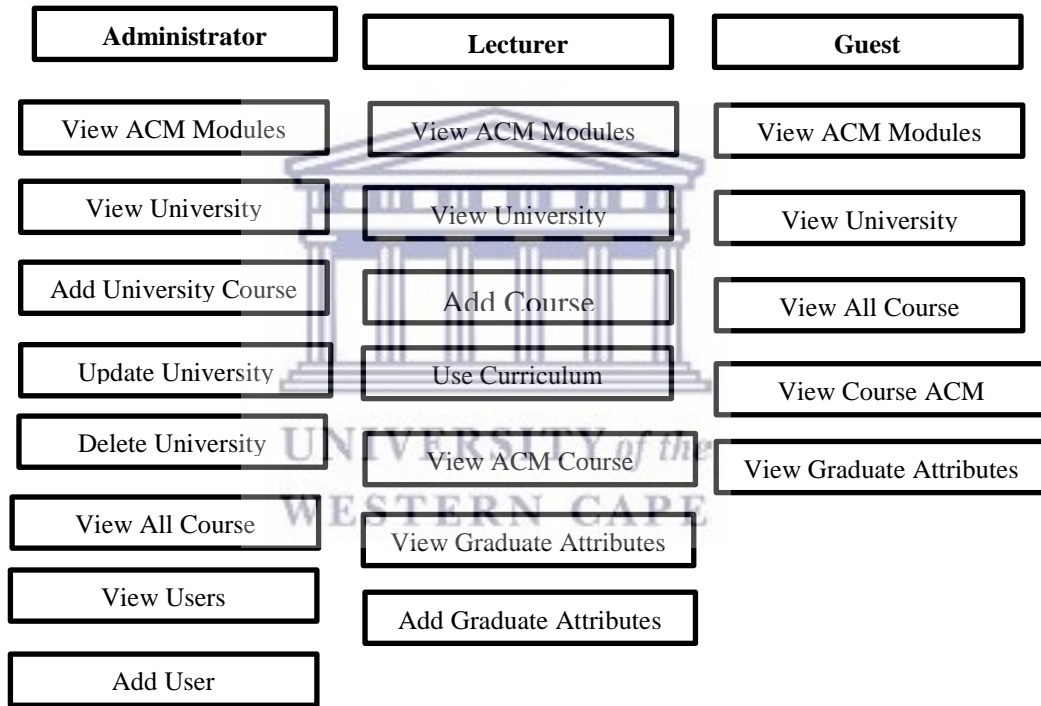


Figure 22: Functionality of ACM calculator

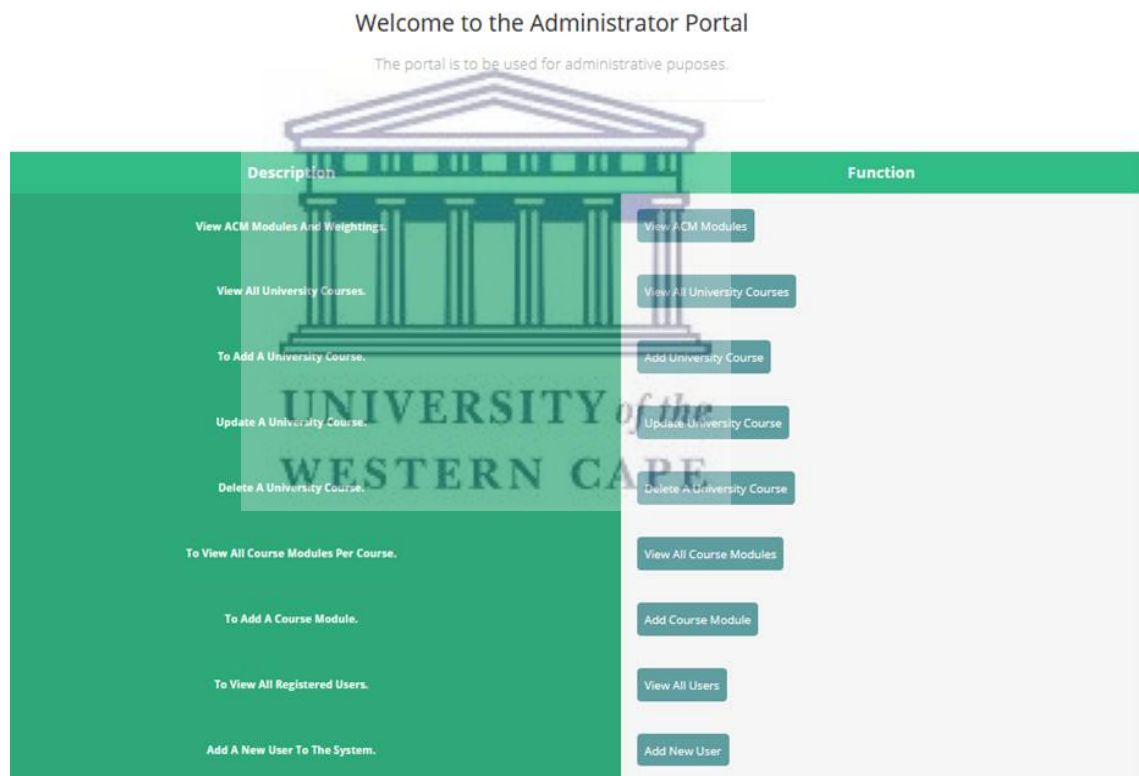
The system should allow for one (1) administrator per university or per department. The administrator has overall control of the system for that university. The system should allow for many lecturers, who teach many university courses and have elevated privileges. The system should allow many guests to access the system with limited privileges. A proof of concept portal was developed with

HTML, *CSS*-based design templates, *PHP* and additional *JavaScript* (see Figure 22). In this proof of concept the functionality is as follows:

Administrator Role: This is initialized by the web-site or framework owner when the system is rolled out, and the database is setup. All other users are added by the administrator. The administrator also adds or deletes all the course codes and the course modules of the programmes offered by the university or department (see Figure 23).

Welcome to the Administrator Portal

The portal is to be used for administrative puposes.



Description	Function
View ACM Modules And Weightings.	View A CM Modules
View All University Courses.	View All University Courses
To Add A University Course.	Add University Course
Update A University Course.	Update University Course
Delete A University Course.	Delete A University Course
To View All Course Modules Per Course.	View All Course Modules
To Add A Course Module.	Add Course Module
To View All Registered Users.	View All Users
Add A New User To The System.	Add New User

Figure 23: The Administrator's Portal

Lecturer and Guest Roles: A guest can only view everything; they cannot add anything or make any changes. A lecturer can only edit what he or she teaches, and they can add the hours to the lectures, tutorials or practicals. A lecturer can view everything (see Figure 24) and (Figure 25).

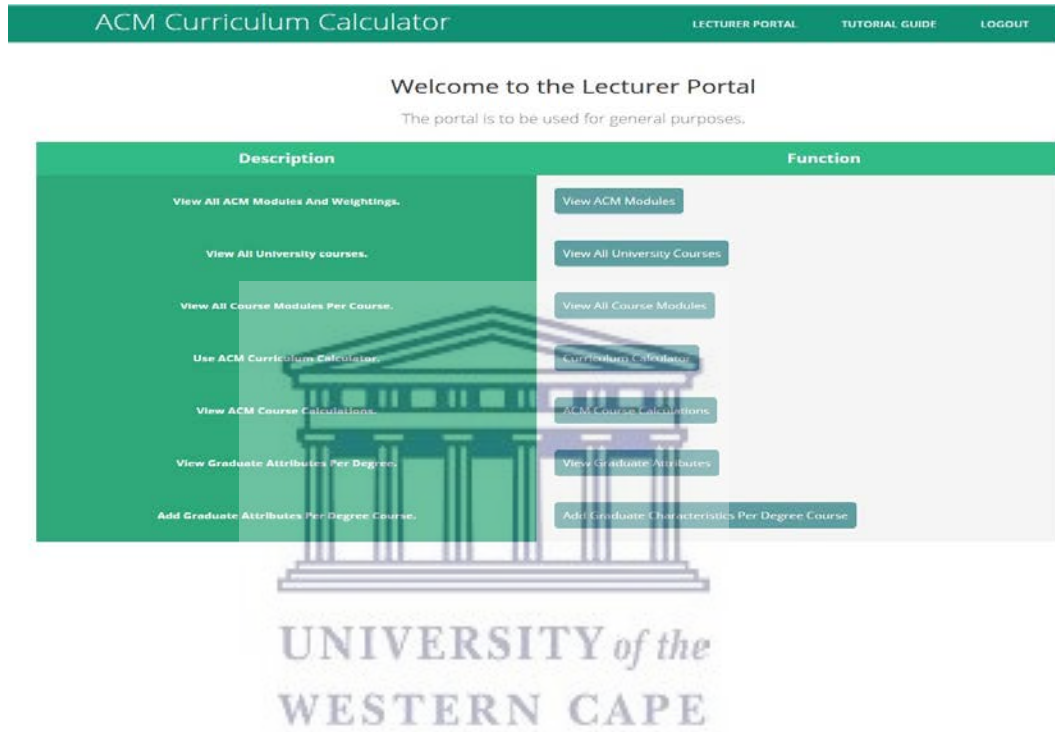


Figure 24: The Lecturer Portal

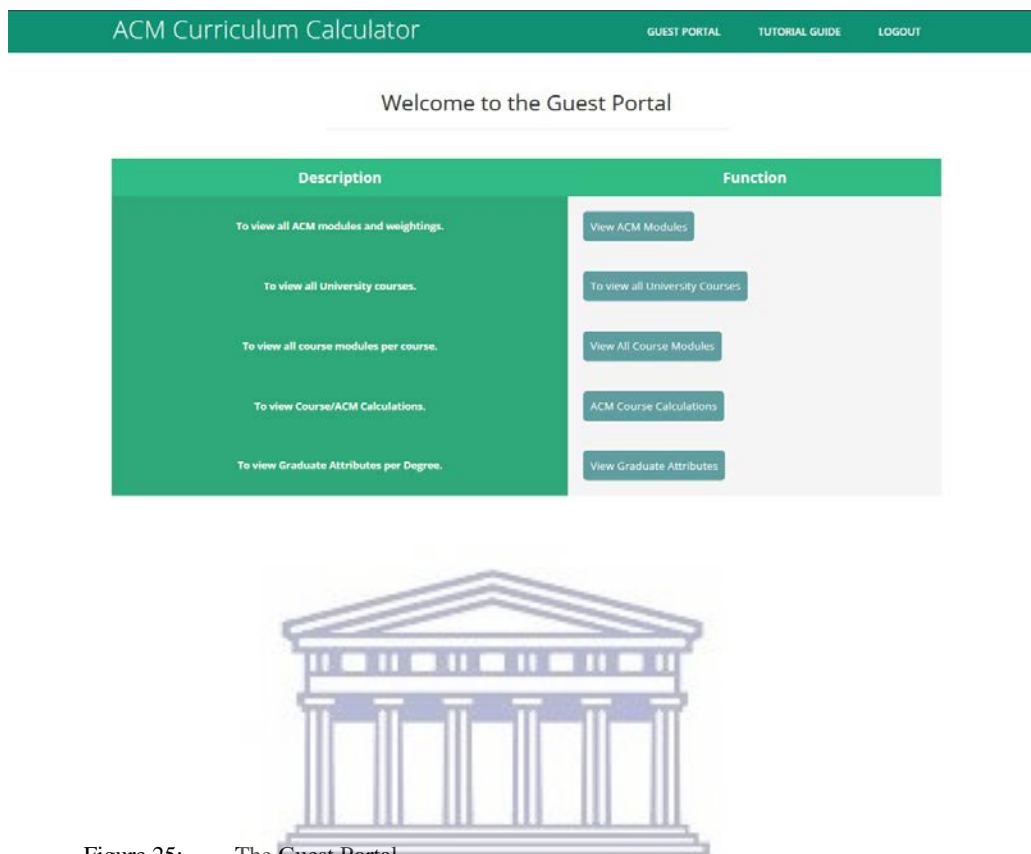


Figure 25: The Guest Portal

Any person assigned to one of the roles (Administrator, Lecturer and Guest) has to undergo authentication using an assigned username and password. See below for role creation and activation responsibilities (see Table 8).

Table 8: the role of the creation and activation responsibilities

Role	Creation	Activation
Administrator	System Initialization	System Initialization
Lecturer	Administrator	Administrator : Email
Guest	Administrator	Administrator : Email

STEP 4 EVALUATION

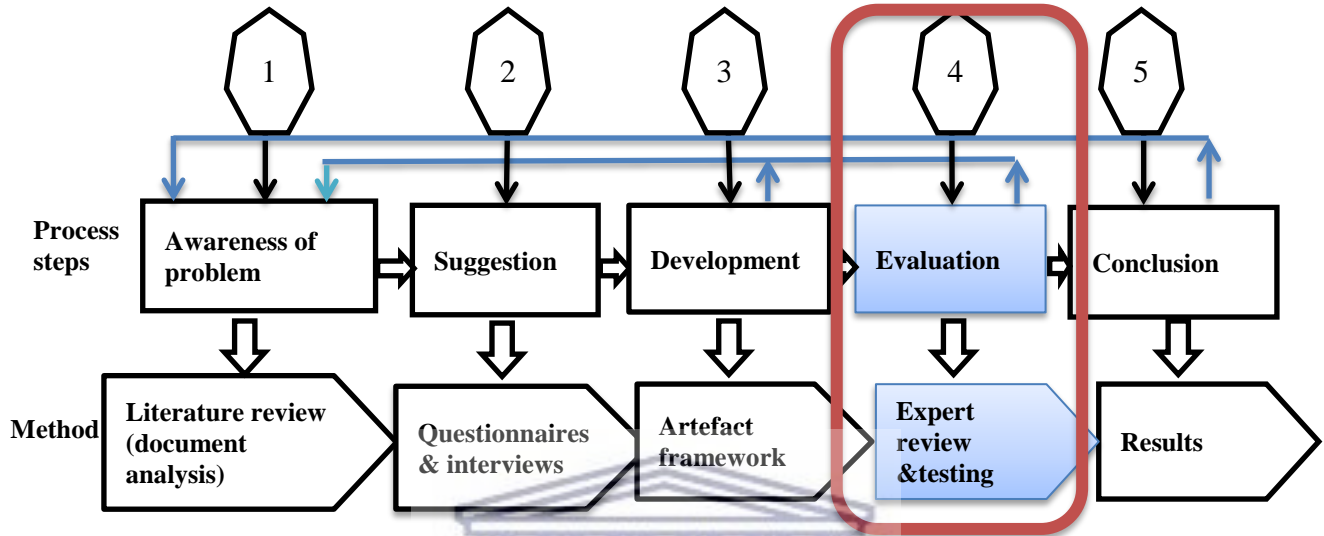


Figure 26: Expert review and testing within DSR proses

Expert review and testing

Five experts were approached to review the artefact which is not a fully developed system but was developed as a proof of concept, to get feedback from the experts. The five experts; a qualified specialist at a university in Libya, two at higher institutions in Libya (HTVI) and two from the University of Western Cape, were asked to consider the artefact. They were given three tasks to execute keeping in mind five heuristics, namely: visibility of system status; aesthetic and minimalist design; help and documentation; user control; and freedom (see Figure 26).

Task 1: The participant was expected to log in as an administrator and browse to view the modules as prescribed by the ACM. They could also view the courses that had already been entered into the system. Participants were required to add two modules to a course (COS255) namely: Fundamental Concepts and Information systems. Once the task was completed they were required to submit the modules. Participants could update the course duration, lecture hours, tutorial

hours and practical hours that already existed. They could delete a university course which would also delete the modules of that particular course.

When asked about their experiences of Task 1, one of them indicated that *“it is a good idea and easy to use”*. Most of participants strongly agreed that it was easy to complete the task. They were also satisfied with the feedback once each step was completed. When asked whether the data correctly updated on the system, all of participants agreed that it was.

Respondents noted that the functionality of the system was satisfactory. In a question that asked whether all the added information was displayed correctly all of the participants responded in the affirmative.

Task 2: Participants were expected to log in as a Lecturer and consider how the programme compared with what the ACM suggests. They could view a calculation to determine how this programme compares with the ACM curriculum. It showed them the characteristics of graduate attributes which are recommended by ACM IEEE which need to be attained, at least at the elementary level of undergraduate CS programs.

When the respondents were asked about their experience of Task 2, one participant said that *“it is a good idea to use this prototype to know how we compare with the ACM”*. Most of participants (80% strongly agreed and 10% agreed) that the layout—text, graphics and links—were user friendly (see Figure 27).

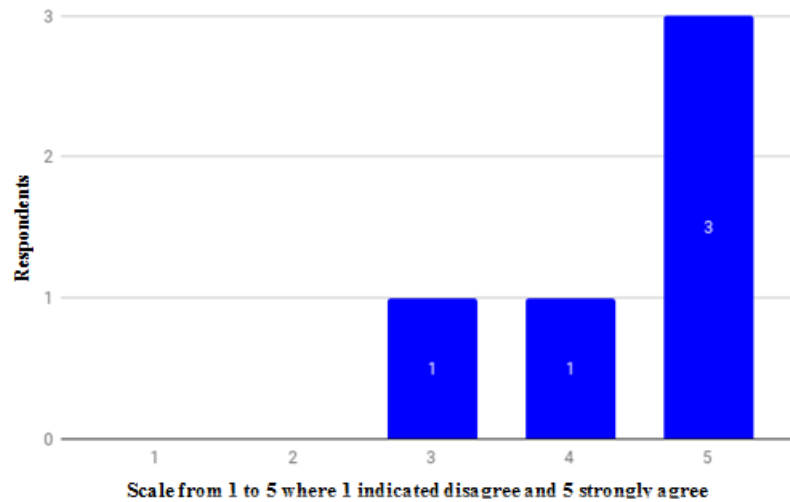


Figure 27: The layout of text, graphics and links were user friendly

All participants agreed that it was easy to understand what action each tool performed. When asked about the usefulness of being able to compare courses with the ACM knowledge areas, 80% of participants agreed that it is useful, and only 20% did not see the necessity of comparing their courses with those of the ACM. Most of participants (60%) agreed that the proof of concept system provided them with the necessary feedback whilst only 20% disagreed with this statement.

Task 3: The participants were asked to log in as a Guest and view the ACM module. They were expected to browse and view all course modules. They could view all university courses as well as Course/ACM Calculations that indicate graduate attributes per degree.

When the respondents were asked how they experienced task 3 one participant indicated that “The user needs to be notified that the email has been sent to his/her address”. Some of the participants (40%) strongly agreed and (20%) of participants agreed, whereas (40%) of participants disagreed when asked whether

the system has all functions that they expected. In a question that asked whether the speed of response to actions performed was suitable, (60%) strongly agreed whereas only (20%) of participants agreed. When asked whether the tutorial was logical and understandable, (40%) of participants strongly agreed and (20%) agreed whereas only (20%) of participants disagreed (see Appendix L).

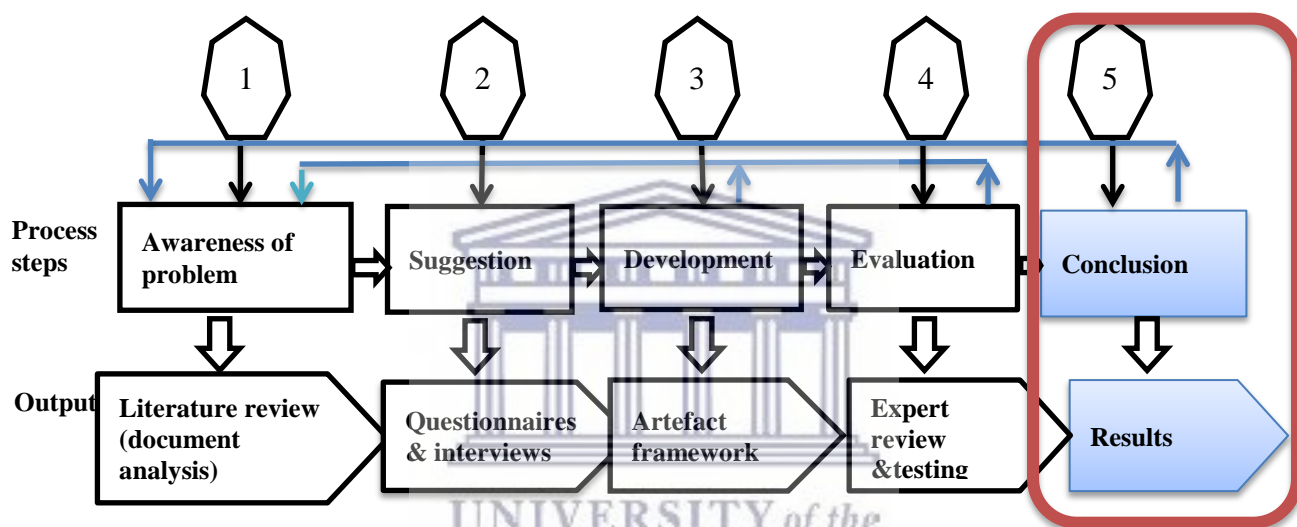


Figure 28: Result within DSR proses


STEP 5 CONCLUSION

Result

As illustrated in Figure 28 a framework has been developed for an online system and a proof of concept has been programmed. The framework will assist programmers to develop a complete system with the intention of assisting curriculum developers align their CS curriculum with that of the ACM. The results of this study will be used to advise policy makers and curriculum development specialists in Libya on how the current curriculum could be adapted so that graduate students from Libyan universities can become globally competitive. In In Figure 29 and Figure 30 some results are shown.

All ACM Curriculum Calculations Per University Course

Username	ACM Course Hours	Course Code	Course Name	University Course Hours	Feedback
mhenney	10	COS101	Computer Science 1	196	Your course hours are above the ACM standard for this course.
ahadi	14	COS255	Computer Science 255	49	Your course hours are above the ACM standard for this course.



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Figure 29:

Results of all ACM curriculum calculation course

ACM Curriculum Calculator										
LECTURER PORTAL TUTORIAL GUIDE LOGOUT										
Graduate Attributes per Degree Course										
The following graduate attributes are recommended by ACM IEEE and should be attained at least at an elementary level by graduates of computer science programs.										
Degree	Knowledge Application	Analyze Logically	Ethical and Responsible Behaviour	Communication Skills	Teamwork	Project Management	Manage Ambiguity And Complexity	Programming Skills	Continued Learning	Critical Attitude
B.Sc Computer Science	1	1	0	0	1	1	1	1	1	1
B.Sc Mathematics	1	1	1	0	1	1	1	1	1	1
CSC211	1	0	1	0	1	0	0	0	0	0
CSC311	1	1	1	0	0	0	0	0	0	0
B.Sc Computer Science	1	0	0	0	0	0	1	0	0	0

Figure 30: Results of graduate attributes per degree course

Summary

This chapter discussed the findings from the questionnaires and interviews that were conducted in this study. The findings were discussed in relation to the research questions and were compared with the findings from the literature in chapter two. The findings were also discussed in the context of the prototype that was developed for this study and feedback from interviewees was presented. The next chapter will discuss the conclusions and recommendations of the study.

Chapter 5

DISCUSSION AND CONCLUSION

Introduction

In Chapter 1 a research question was posed and broken down into sub-questions. These sub-questions will now be revisited and “*answered*” in terms of the research that was done. The quality of the interpretation of the research done, as well as the methods that were implemented, will then be evaluated. Finally, the contribution this study makes to the body of knowledge currently available in the information technology field will be discussed.

Revisiting the research questions posed in Chapter 1

Several questions were posed in Chapter 1 in order to break down the larger goal:

How should the Libyan Higher Technical and Vocational Computer Science curriculum be transformed to be aligned with international trends?

The constituent parts of this objective are represented by each of the posed questions. Each of the asked questions will now be considered together with the study’s findings.

GRADUATE ATTRIBUTES

The posed question

What graduate attributes should be acquired by Computer Science students?

Findings

This study found that a majority of participants perceived practical knowledge to be valuable and that theoretical knowledge alone was not enough. Fifty eight percent of the respondents felt that theoretical knowledge is important. The

majority of the respondents thought that it was essential for graduates to understand how to logically solve a problem and they responded positively to the proposition that graduates needed to possess ethical and professionally responsible attributes.

These responses are consistent with the literature that argues that Libyan graduates need to be able to apply their knowledge, that they must be technically savvy, and be able to solve complex problems without having to rely on theoretical knowledge only (Impes, Othman, Wilson, & Pislaru, 2014). Findings from this study are also aligned with the thinking of Kirdar, who argues that when analysing problems graduates ought to do so logically (Kirdar, 2017). Graduates are also required to act ethically and professionally at their workplace. Effective communication skills are another requirement that employers look for.

SKILLS REQUIRED IN THE LIBYAN WORLD OF WORK

The posed question

What attributes does the workplace require from Libyan graduates?

Findings

The study found that the respondents wanted more programming languages to be introduced in order to be attractive to employers and they also wanted to be introduced to a variety of operating systems. In terms of leveraging skills for the workplace, the majority thought that their college/university education could address these skills more effectively by focusing on network problem solving skills and Graphical User Interface courses that would allow them to design websites. Findings also revealed that more training in the maintenance of hardware is needed and respondents thought that universities could invest more on web programming skills. Respondents also took the opportunity to emphasize that technical skills were more applicable in their workplace than theory. The

respondents favoured CS in terms of applicability to the workplace but respondents cautioned that university CS curricula should be updated in accordance with new developments in the industry.

ALIGNMENT OF CURRICULA

The posed question

How does the curriculum of Libya align with curricula from other countries and the ACM/IEEE?

Findings

The study compared different curricula from ACM IEEE, University of the Western Cape, University of Sydney, Victoria University and Computing Curricula in Sub-Saharan Africa and discovered salient differences with regards to, technical understanding of CS, problem solving skills and communication and organisational skills. Findings from the interviews showed that the CS programmes offered by the HTVIs in Libya, do not contain all of the eleven graduate attributes as outlined by the ACM curriculum. The study found that the CS programmes in Libya failed to expose students to some, and in some instance to any, of these graduate attributes. Consequently, the programmes of HTVIs in Libya do not prepare students for: life-long learning; do not inculcate problem solving skills and do not focus enough on enhancing CS course modules to equip students with communication skills or team work. In many cases these soft, but basic, CS skills, were regarded as unimportant. Libyan students are thus in many cases ill-prepared for the workplace.

The findings of the study showed that the government and the Ministry of Higher Education were perceived to be the responsible parties for curriculum development, but should keep international standards in mind. All of the participants agreed that university CS curricula should do more to align with international advancements of curricula. Interviewees said that teaching staff

members should belong to research units that were affiliated to international bodies. The interviewees suggested that this would make it easier for them to keep up to date with revised curricula. Industry could contribute to the development of student skills by funding internships and forming partnerships with the institutions.

The findings are consistent with the findings from the literature review that Libyan curricula have not kept up to date with the most recent developments in the field and thus are not relevant in this fast-changing world (Impes, Othman, Wilson, & Pislaru, 2014). This is problematic as employers require that graduates are knowledgeable and have skills such as: good communication skills; problem-solving skills; critical and analytical thinking; ability to work in a team; willingness to learn; good interpersonal skills; and the ability to work in a modern organization.

INPUTS FOR SUCCESSFUL GRADUATE OUTPUTS

The posed question

What factors would contribute to the development of specific graduate attributes?

Findings

Findings from this study showed that the factors that were paramount to developing quality graduates were those skills acquired whilst at university. Among those which respondents felt were indispensable were basic software programming skills. Respondents further indicated that it was important to have the ability to use web applications, java script and multi-media. In addition, one added that English is very important, whereas another added that solving mathematical problems was also important. The majority of respondents indicated that they acquired communication skills working as a team at their place of employment. Some reported that they acquired the skill to solve networking

problems and they were now able to deal with different operating systems such as iOS, Linux and UNIX.

Scholars support these factors in the literature and argue that tertiary instruction ought to be focused on preparing and teaching a workforce that is adaptable and able to adjust to the ever-changing innovative work milieu (Zuboff, 1988).

Evaluation of contribution

Whetten (1989), previously the editor of the AMR (Academy of Management Review), wrote an article in which he considers the necessary ingredients of a theoretical contribution. The evaluation of this study used Whetten (1989) and Venter (2000) by suggesting that new knowledge from CS research can be applied beyond the limits of physical borders and be generalised to some extent to parts of the world that experience the same problem statement posed herein (Whetten, 1989) (Venter, Group constitution for small group learning in the field of information technology., 2000).

Whetten posed a few questions:

What's new?

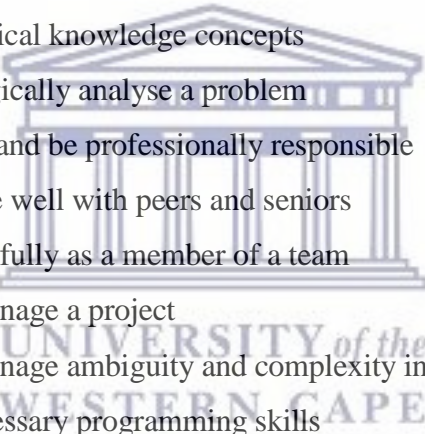
Does the study make a significant contribution to current thinking?

With the 4th industrial revolution on our doorstep the current thinking is that it will change our lives completely technologically. It is therefore important that Libya also changes her approach to the teaching of CS in order to be part of this revolution.

Libyan HTVIs have indicated that it is important to deal with program expertise, and the possession of programming skills has been perceived to be essential when dealing with graduates. HTVIs have built on the idea that graduates need to be

prepared to learn throughout their careers in order to be at the cutting edge of technology. This has emboldened and elevated critical attitudes towards knowledge, and is a requirement in Libyan HTVIs. Although a number of computer scientists reported not to have attended courses or to have read articles on computer ethics, it was found that HTVIs do instil the values of integrity and honesty in CS graduates.

A recurring list of skills, that were thought to be indispensable, emerged from HTVIs in Libya. These have been defined by the ACM IEEE and other universities. The most predominant skills are the following:

- 
- Value theoretical knowledge concepts
 - Be able to logically analyse a problem
 - Act ethically and be professionally responsible
 - Communicate well with peers and seniors
 - Work successfully as a member of a team
 - Be able to manage a project
 - Be able to manage ambiguity and complexity in assigned tasks
 - Have the necessary programming skills
 - Learn throughout their careers in order to be at the cutting edge of technology
 - Have a critical attitude towards knowledge
 - Have integrity and be honest

CS industrialists in Libya believed that basic software programming skills such as the ability to use web applications, java script and multi-media gave graduates a competitive edge in terms of employment in the industry. Findings also revealed that English was very important, whereas another respondent added that solving mathematical problems is important. An alumni of HTVIs found that one contributor to their competitive resumés was communication skills because a skill

was beneficial in terms of team work and partnerships in the industry. The existing curriculum equipped HVTIs in CS with the skill to solve networking problems which meant that they were able to take opportunities to navigate different operating systems such as iOS, Linux and UNIX.

So what?

Will the theory change the teaching of computer-related subjects? Are linkages to research evident? Are solutions proposed for remedying alleged deficiencies in current theories?

The key contributions of this research are:

- A better understanding of the CS curricula in higher education institutions particularly among HVTIs in Libya across a number of criteria (e.g., skills of trained graduates, ability to adapt to internationally standardised CS training, areas of skills shortage, etc.) and the views of educators and ICT industrialists about the alignment of the curriculum with the ACM standard.
- Identification of the resources required by HVTIs in Libya to align the CS curriculum with the international ACM standard as well as the solutions for building information banks and CS skills relevant to the industry, in a constantly evolving environment.
- Recommendations on what needs to be done to align the CS curricula among HVTIs in Libya and how HVTIs can build partnerships with other institutions to create vibrant curricula.

Why so?

Are the underlying logic and supporting evidence compelling?

The scope of the research is confined to the higher education industry particularly HVTIs in Libya. The core contributing criteria which emerged for Libya were used in the study and were found to be generally applicable to these HVTIs since technical, practical and emancipatory knowledge interests were identified which started to populate these categories for the study. The power change aspect of the theory development component was also attended to since, as in the case of Libya, it was revealed that there were now new aspects needing consideration to align CS curricula to international standards which are different from those deemed acceptable in the conventional ICT pedagogies. So, over a period of time, the environment has changed due to the rapidly transforming technological environment.



Well done?

Does the thesis reflect seasoned thinking, conveying completeness and thoroughness?

Chapter 1 introduced the topic of this research. In sketching the background the researcher paid attention to the problem of the content of CS curricula in Libya. This was followed by research questions, the research design and the research contribution. Chapter 2 contained the literature review based on defined key words and concepts. Chapter 3 presented the research design and the research methodology. Chapter 4 presented the results according to the steps of DSR methodology. Chapter 5 was used to review the research using criteria proposed by Whetten (1989). This does indicate thoroughness and reflection on the part of the researcher.

Why now?

Is the topic of contemporary interest to scholars in this area?

Universities in Libya offer CS as a subject, however, it has been noted that graduates are poorly prepared for the job market. Therefore, it is important to promote the development and revision of curricula, adapting the programs to international standards but also to link them to the needs of the Libyan workplace (Sawahel, 2016). Curricular reform for technical and vocational education in Libya will undoubtedly make a contribution to the advancement of the nation's social and economic growth. Currently, Libya has nearly 382 institutions, which offer technical education at various levels, providing education to more than 160,000 students across several disciplines (Impes, Othman, Wilson, & Pislaru, 2014).

Employers require that graduates have qualities such as: good communication skills; problem-solving skills; critical and analytical thinking; ability to work in a team; willingness to learn; good interpersonal skills; ability to work in a modern organization and; graduates who are knowledgeable. This thesis can therefore, contribute to the discourse on whether these attributes can be developed in CS graduates and whether the CS curriculum makes provision for them.

Who cares?

What percentage of academic readers is interested in this topic?

CS education has become very prominent – many scholars are considering how to improve the teaching of CS as it is becoming increasingly significant for the 4th industrial revolution for most people to have some knowledge of CS. The subject has in recent times been considered for inclusion within the compulsory school curriculum. Up to now, a major focus of technologies in the school curriculum has, in many countries, been on applications of existing technologies. Recently, discussions for including computers in the curriculum have shifted to a much greater focus on computing and CS, which is more concerned with the uses of and development of programming, together with fundamental principles of problem-solving and creativity (Passey, 2017).

In the context of initiatives by tertiary institutions, HTVIs in Libya, businesses as well as other stakeholders (UNESCO) in their efforts to establish a standardised and comprehensive CS curriculum, this study has particular relevance, as it augments the data about the issues, that need to be taken into consideration to plan a curriculum, pedagogy and implement standard CS curricula in HTVIs in Libya.

HTVIs in Libya have been seeking to standardise the reform of programs and curricula. There has been a shift away from the traditional way of developing and

approving curricula to a much more centralized system of reforming programs and curricula for higher institutions (Othman, Kashadah, Gosbi, & Khoja, 2012). This centralised system ensures that teaching methods are standardised, as opposed to traditional ways, in which members of the teaching staff tended to use summarised material, rather than referenced material for delivering their curricula. This is primarily because of the expense involved in acquiring referenced materials at a local level, even though a book subsidy policy exists, that has been adopted by individual institutes and universities.

This study identifies positive criteria which have contributed to ACM IEEE success in the developing world as well as negative criteria which have hindered, or had the potential to delay that progress among HTVIs in Libya. The study identifies steps already taken as well as challenges which remain and reports on a survey done among HTVIs as a focus area within Libya. All these help stakeholders who are charged with developing new CS curricula among HTVIs in Libya.

On top of all these institutional efforts, the workplace in Libya requires certain attributes from the graduates that they hire. According to Kirdar (2017), Libyan graduates are required to be able to apply their knowledge, that is, they must be technically savvy and be able to solve complex problems without having to rely on theoretical knowledge only. Additionally, when analysing problems, they ought to do so logically. Graduates are also required to act ethically and professionally at their workplace.

Limitations/challenges

The research was limited to recent CS graduates and stakeholders in the IT sector in Libya so the results cannot be generalised to the rest of Africa. The interviews in this study were conducted in English, but since the home language of most of

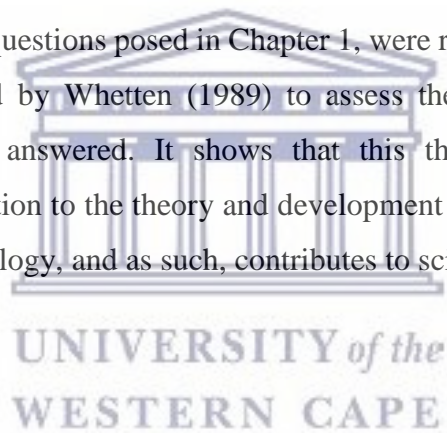
the participants was Arabic, there were instances where aspects had to be clarified to ensure the researcher and the interviewee understood each other. Fortunately, the researcher is also Libyan and where the interviewee required further clarification, the researcher engaged with them in Arabic and translated the interaction into English for processing purposes.

SPECIFIC ASPECTS THAT CAN BE PURSUED

Collaboration with universities in both the developed and developing world and stakeholders in the private sector needs further research.

Conclusion


In this chapter, the questions posed in Chapter 1, were revisited. Furthermore, the questions suggested by Whetten (1989) to assess the quality of a theoretical contribution, were answered. It shows that this thesis makes a legitimate theoretical contribution to the theory and development of Computer Science and Information Technology, and as such, contributes to scientific progress.



APPENDICES

Appendix A

ETHIC CLEARANCE


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DEPARTMENT OF RESEARCH DEVELOPMENT

14 December 2015


To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape approved the methodology and ethics of the following research project by:
Prof J Vanter (Computer Sciences)

Research Project:	The development of computer sciences curricula for higher technical and vocational institutions in Libya.
Registration no:	15/7/238

Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.


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M. Patricia Joubert
Research Ethics Committee Officer
University of the Western Cape

Private Bag XI7, Bellville 7535, South Africa
T: +27 21 959 2900/2940 F: +27 21 959 3170

Appendix A

Appendix B

SAMPLE LIBYAN CURRICULA

مصفوفة المواد بقسم هندسة البرمجيات

جدول الوحدات الدراسية المقررة / قسم هندسة وتطوير البرمجيات.

Term3	Subject	Hours	Prerequisite
IT 100	IT Essentials	3/3	None
IT 111	Fund. of Programming in C	4/0	None
CT 113	Electrical Circuits 1	4/0	None
MA150	Mathematics 1	4/0	None
EN 160	English Language 1	4/0	None
Total Credit: 20			22

Term2	Subject	Hours	Prerequisite
CT 115	Computer Organ./Architect	4/0	IT 101
IT 112	Programming in Visual C	3/3	IT 111
CT 117	Digital Systems	3/3	None
MA 151	Mathematics 2	4/0	MA 150
EN 161	English Language 2	4/0	EN 160
Total Credit: 20			24

Term3	Subject	Hours	Prerequisite
IT 211	Object Oriented Prog. II (C++ / Java)	3/3	IT 112
MA 254	Discrete Math & Structure	4/0	CT 117
IT 214	Introduction to Information Systems	4/0	None
MA 256	Probability & Statistics	4/0	MA 151
EN 262	English Language 3	4/0	EN 161
Total Credit: 20			22

Term2	Subject	Hours	Prerequisite
IT 212	Object Oriented Prog. II (C++ / Java)	3/3	IT 211
IT 216	Data Structure & Algorithms	3/3	IT 112
IT 218	Database Systems Concepts	3/3	IT 214
IT 220	Operating Systems	3/3	CT 115
EN 263	English Language 4	4/0	EN 262
Total Credit: 20			28

Term3	Subject	Hours	Prerequisite
IT 310	Application Development	3/3	IT 212
IT 312	System Analysis & Design	3/3	IT 218
IT 319	Advanced Database Systems	3/3	IT 218
NT 320	Fundamentals of Networking	3/3	None
EN 364	English Language 5	2/0	EN 263
EN 300	Technical Documentation 1	2/0	EN 263
Total Credit: 20			28

Term2	Subject	Hours	Prerequisite
IT 314	Human Computer Interaction	4/0	IT 100
IT 316	Mathematics Technology	3/3	IT 212
IT 311	Web Application	3/3	IT 212
NT 319	Internet Security	4/0	NT 320
EN 365	English Language 6	2/0	EN 364
EN 301	Technical Documentation 2	2/0	EN 300
Total Credit: 20			24

Term3	Subject	Hours	Prerequisite
IT 410	Business Process Modeling	3/3	IT 312
IT 412	Fundamentals of Software Engineering	4/0	IT 312
IT 414	Elective 1	3/3	None
IT 420	Project Management	3/3	None
CT 416	Research Methods	2/0	None
Total Credit: 18			24

Term2	Subject	Hours	Prerequisite
IT 416	Professional Intern	3/3	None
IT 404	On Field Practice	1/3	None
IT 413	Research Thesis	0/3	All Sub.
Total Credit: 7			18

Total Credit Units =145

- Refreshment year (semester 1 & 2) is general for all departments.
- Subject Code:

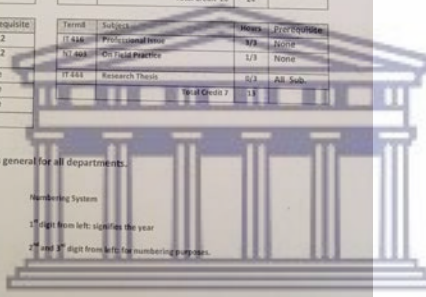
Subject Code Abbreviations

EN	English Language subjects
MA	Mathematics subjects
IT	Information Technology Dept.
NT	Networking Dept.
CT	Control Dept.

Numbering System

1st digit from left: signifies the year

2nd and 3rd digit from left: for numbering purposes.



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Appendix C

QUESTIONNAIRE 1

The development of computer science curricula for higher technical and vocational institutions in Libya

Background of the respondent

Section 1

Please answer some background questions

1-I studied at the following institution:

- Tripoli
- Benghazi
- Misrata
- Zawiya
- Tarhona
- Bani Waled
- Sabha
- Other



If other please give the name -----

2- I graduated with the following qualifications :(you can mark more than one

Appendix C

- Higher Diploma Degree
- Bachelor Degree
- Master's
- Degree
- PhD Degree

3-For most of my studies the language of tuition was

- Arabic
- English
- French
- Other



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If other language please give the name -----

4-How many years have you been working since first qualifying?

- 1.1 year
- 2.2 year
- 3.3 year
- 4.4 year
- 5.5 year

5-What is your position in your current company?

1. Associate Computer Engineer
2. Technical Computer Engineer
3. Senior Computer Engineer
4. Consulatant Computer Engineer
5. Other

If other please give the name -----

6-How long have you been working for the company?

0 year

1 year

2 year

3 year

4 year

5 year or more

Section 2 of 2

You graduated from your university or tertiary institution, with technical skills that you acquired during your studies. The following questions are intended to

Appendix C

elicit how you feel your skill-set prepared you for the workplace (This is not a rating of your current knowledge).

1-Rate your technical understanding of Computer Science after graduating on a scale of low 1 to high 5.

2- Answer yes or no for each of the following question: Do you understand what is meant by:

Abstraction: Yes No

Complexity: Yes No

Evolutionary change: Yes No

Sharing resources: Yes No

Security: Yes No

Concurrency: Yes No



3-Do you feel that the theory that you have learnt during your studies prepared you for the practical requirements of your work-place. Rate your answer on a scale from low 1 to high 5

4-Did your qualification prepare you for thinking at multiple levels of abstraction and detail? Rate your answer on a scale from low 1 to high 5

5- Rate your communication skills at the time that you graduated to explain computer solutions to others. Answer on a scale from low 1 to high 5

6- During your studies were you involved in at least one substantial programming project?

- Yes
- No

7- Do you now read books or articles about computing?

- Yes
- No

8- Do you think you are up to date with the latest developments in computing? Rate your answer on a scale from low 1 to high 5

9- Have you recently attended or participated in a computing conference or competition or course?

- Yes
- No



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10- During my studies I attended a course that dealt with social, legal and ethical aspects of the discipline of computing.

- Yes
- No

11- Have you recently given a presentation to a larger audience about technical problems and their solutions?

Appendix C

Yes

No

12-Do you have a personal web-page or a blog?

Yes

No

13-Have you used a high performance cluster in your workplace?

Yes

No

14-Have you ever consulted an expert in a domain outside your personal area of expertise?

Yes

No



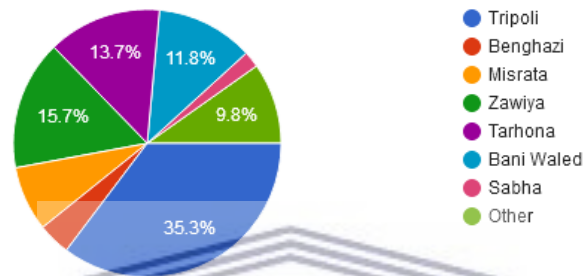
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Appendix D

QUESTIONNAIRE 1 RESULTS

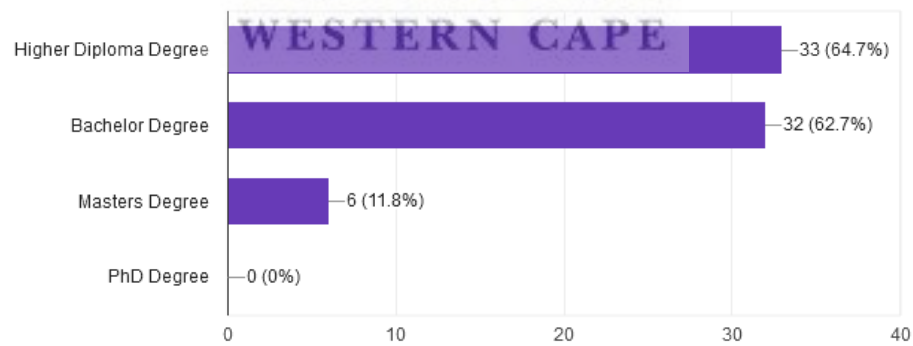
1-I studied at the following institution:

51 responses



2- I graduated with the following qualifications:(you can mark more than one)

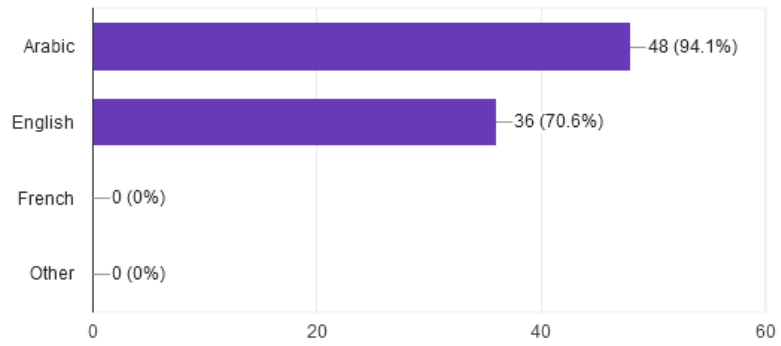
51 responses



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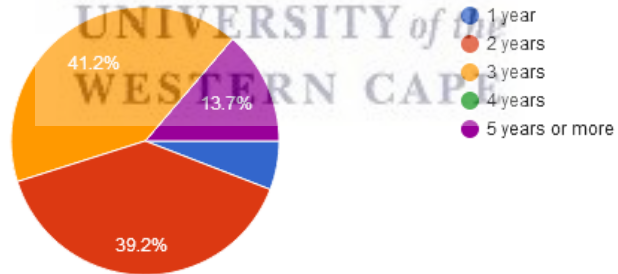
3-For most of my studies the language of tuition was

51 responses



4-How many years have you been working since first qualifying ?

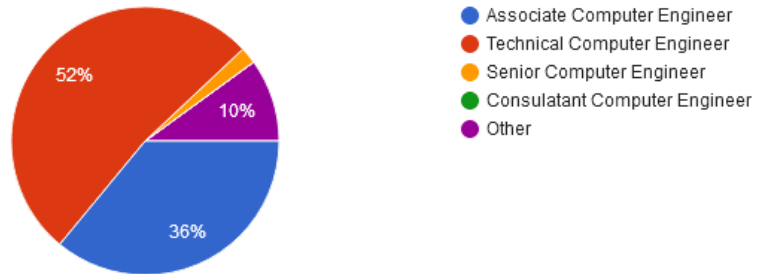
51 responses



Appendix D

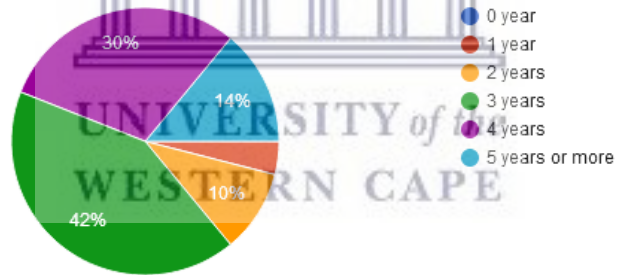
5-What is your position in your current company?

50 responses



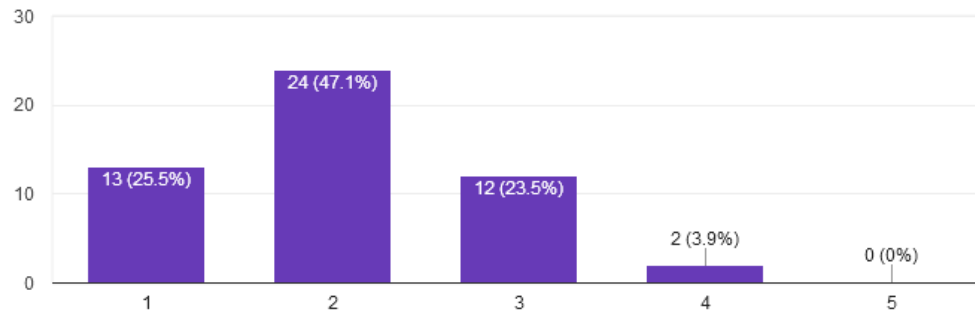
6-How long have you been working for the company?

50 responses



1-Rate your technical understanding of computer science after graduating on a scale of low 1 to high 5.

51 responses



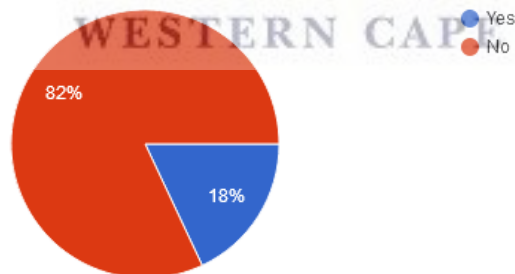
2- Answer yes or no for each of the following question: Do you understand what is meant by

Abstraction

50 responses

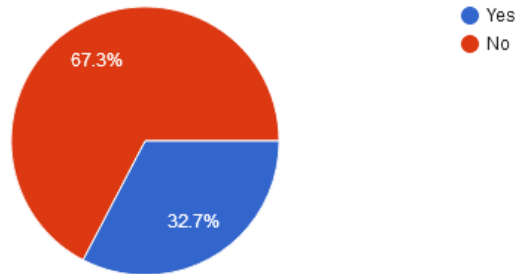


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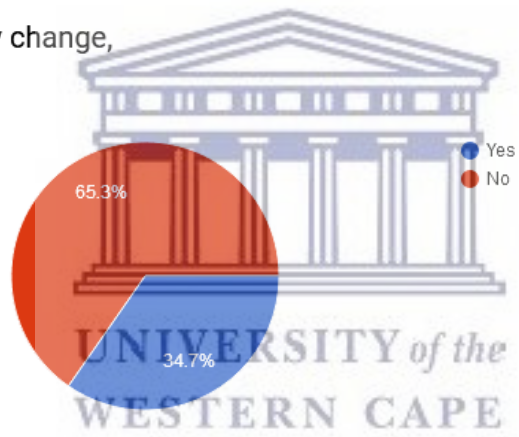


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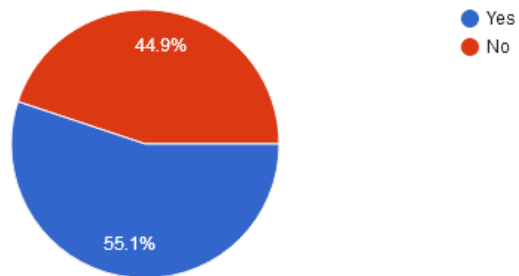
Complexity,
49 responses



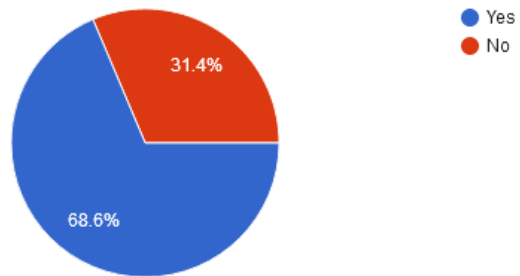
Evolutionary change,
49 responses



Sharing resources;
49 responses



Security,
51 responses



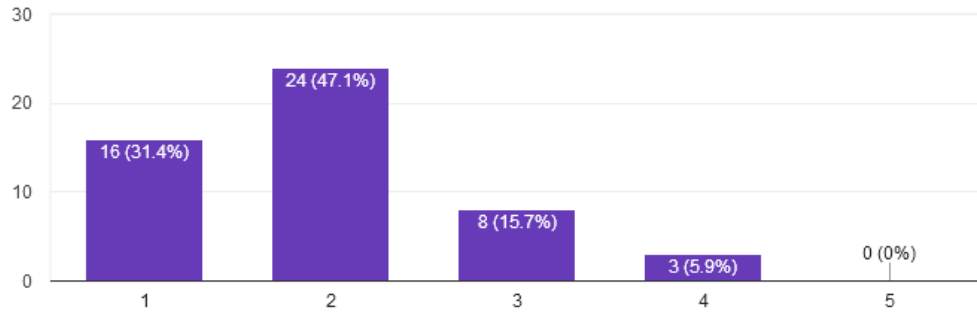
Concurrency
51 responses



Appendix D

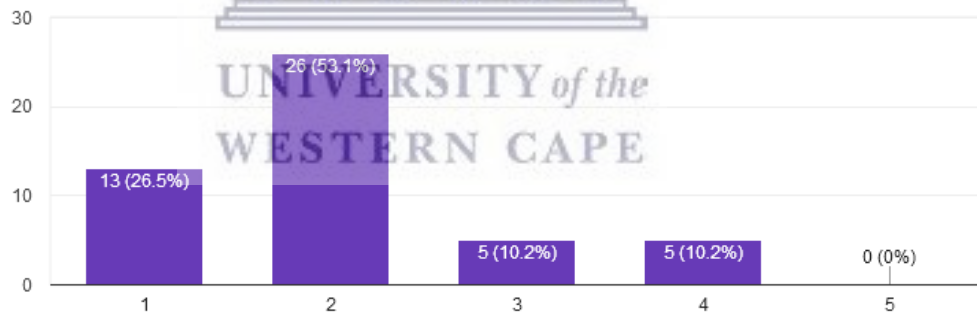
3-Do you feel that the theory that you have learnt during your studies prepared you for the practical require...answer on a scale from low 1 to high 5

51 responses



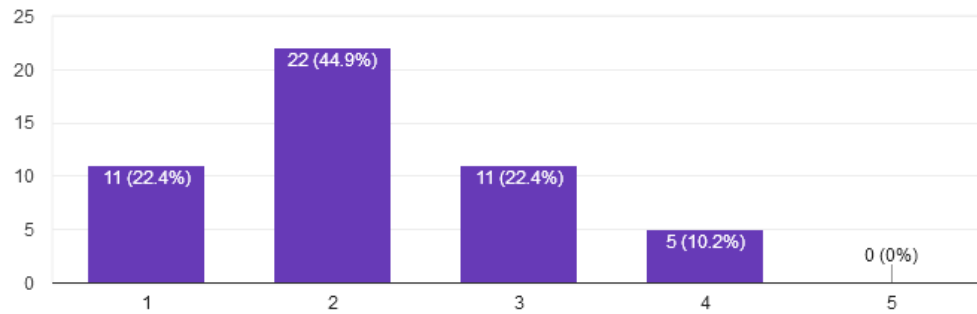
4-Did your qualification prepare you for thinking at multiple levels of abstraction and detail? Rate your answer on a scale from low 1 to high 5

49 responses



5- Rate your communication skills at the time that you graduated to explain computer solutions to others. Answer on a scale from low 1 to high 5

49 responses



6- During your studies were you involved in at least one substantial programming project?

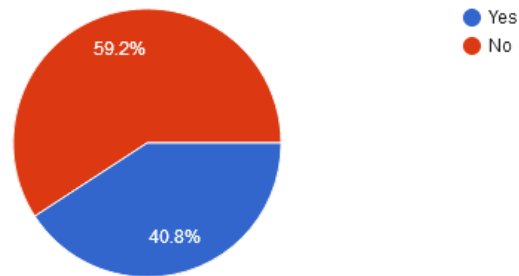
51 responses



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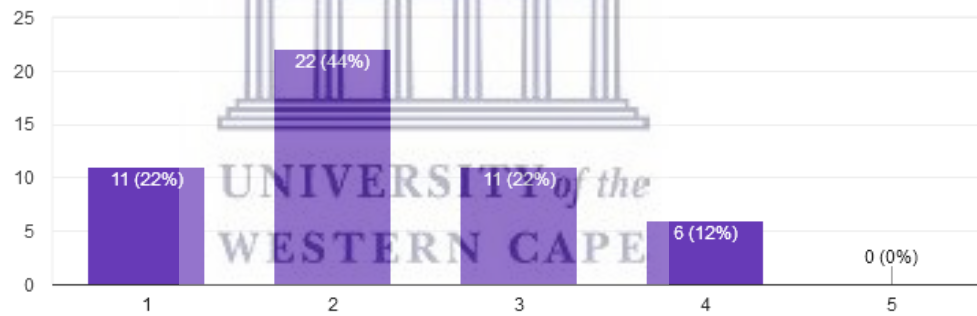
7- Do you now read books or articles about computing?

49 responses



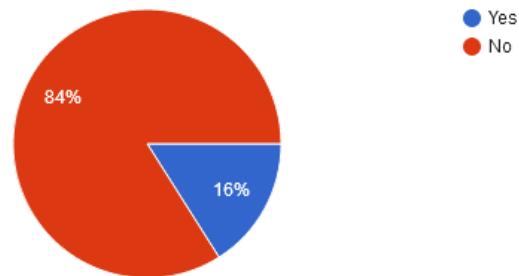
8- Do you think you are up to date with the latest developments in computing? Rate your answer on a scale from low 1 to high 5

50 responses



9- Have you recently attended or participated in a computing conference or competition or course?

50 responses



10-During my studies I attended a course that dealt with social, legal and ethical aspects of the discipline of computing.

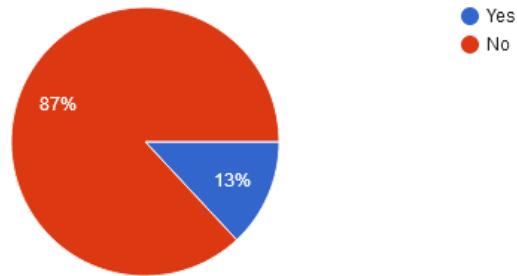
50 responses



Appendix D

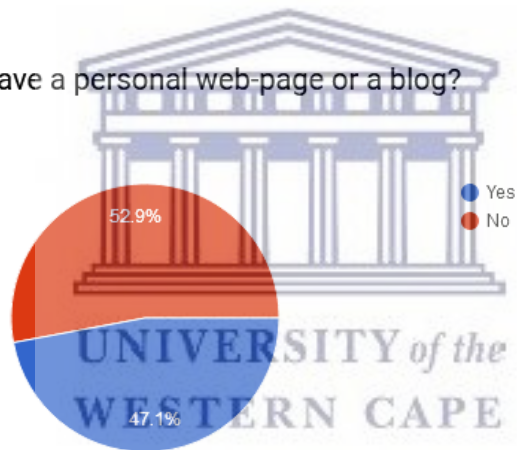
11-Have you recently given a presentation to a larger audience about technical problems and their solutions?

46 responses



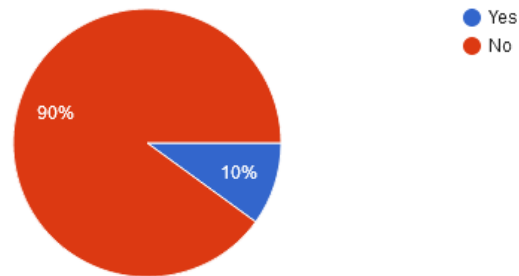
12-Do you have a personal web-page or a blog?

51 responses



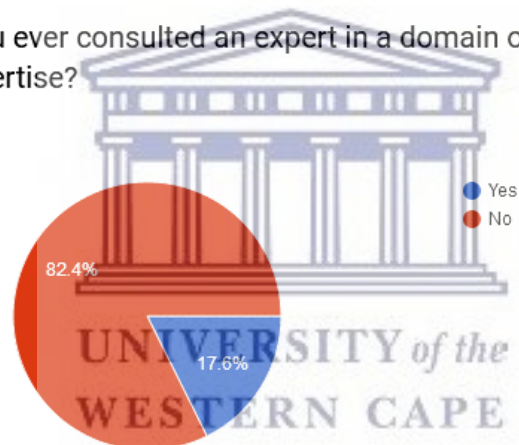
13-Have you used a high performance cluster in your workplace?

50 responses



14-Have you ever consulted an expert in a domain outside your personal area of expertise?

51 responses



Appendix E

QUESTIONNAIRE 2

صفات المتخرجين (Graduate attributes definition)

Graduate attributes are defined as the qualities, skills and understanding that students should acquire during period of their studies duration at an educational institution. These attributes are usually recommended by a university community with the aim of helping the students to make a contribution to their profession and society. Furthermore, these qualities also play a role in the preparation of graduates as future agents of social good (Simon C & Barrie, 2004)

Example

The most important skills should graduate attributes have after graduate:

Technical Skills

Programming Skills

Project experience

Commitment to lifelong learning

Commitment to professional responsibility

Communication skills and team work



Please write down

What do you think the most important skills for graduate attributes in computers science in Libya should be?



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Appendix F

QUESTIONNAIRE 2 RESULT

Libyan graduate attributes skills

- السلام عليكم
- عقد اجتماع مع بعض هيئة التدريس في بعض المعاهد العليا حول مميزات الطلبة المتخرجين ولقد تم مقابلة أكثر من 40 عضوا هيئة تدريس من أكثر من 4 معاهد وتم مناقشة ماهى المهارات التى يجب على الطالب التحصل عليها عند التخرج وتم الموافقة على لاتي
- 1- يجب التركيز على الجانب العملى اكثر من النظرى
 - 2- الاعتماد على النفس
 - 3- العمل مع الاخرين فى حل المشاكل
 - 4- تطوير المهارات من خلال العمل
 - 6- التركيز على مهارات البرمجية
 - 7- التركيز على احترام العمل من المهنية والسرية
- ايضا تم مناقشة هذة المهارات مع بعض الخبرات من شركات النفط وايضا مع بعض اصحاب بعض المصانع 6 ارباب اعمال 7خبرة ورؤساء اقسام فى الشركات وحيث تم الموافقة
- 1- المهنية وسر العمل
 - 2- التعلم بسرعة نظرا لتغير التكنولوجيا بسرعة
 - 3- حل المشاكل باسرة مع الاخرين والتواصل معهم
 - 4- التركيز على الجانب العملى
 - 5- التركيز على البرامجيات
 - 6- الاعتماد على النفس
 - 7- يجب على المتخرج معرفة بعض الامور الادارية

The questionnaires were done with some member factually in 4 high institutions in computing discipline. There were more 40 members attended the interviews. the discussion was about what the important skills for graduate attributes in Libya should be ?

The interviewees observed that:

Technical Skills (concentrating in technical skills more than theory)

Commitment to professional responsibility (ethic issue and society)

Communication skills and team work

Commitment to lifelong learning (graduate should learn during their work because the technology changing fast.

Programming Skills:

Appendix F

Also the interviewer discussed the questionnaire with 6 workers and the head of IT in Oil Company, as well as 7 persons that own a small IT company. All of them were asked about what skills they would require of a graduate. That is what graduate attributes are important?

They mentioned the following:

Lack of technical skills

Poor communication skills

Team working and problem solving

Lifelong learning

Commitment to professional responsibility

Basic skills in term of management

Lack of programming skills



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Appendix G

QUESTIONNAIRE 3

Occupation	
Qualification	
No of years worked	

How important do you think the following graduate attributes would be for a Computer Science student in order to be employed in Libya or internationally? Please rate your answer from 1 to 10, where 1 indicates it is not important and 10 that it is important.	
Graduate attribute	Your rating
Graduates must be able to -	
apply their knowledge (thus be technically savvy) and must not only have theoretical knowledge	
logically analyse a problem	
act ethical and professionally responsible	
communicate well with peers and seniors	
work successfully as a member of a team	
manage a project	

Appendix G

manage ambiguity and complexity in assigned tasks	
program and should have the necessary programming skills	
Graduates must be prepared to learn throughout their careers in order to be at the cutting edge of technology	
Graduates must have a critical attitude towards knowledge	
Graduates must have integrity and be honest	
Graduates must have an appreciation for business aware and its application	



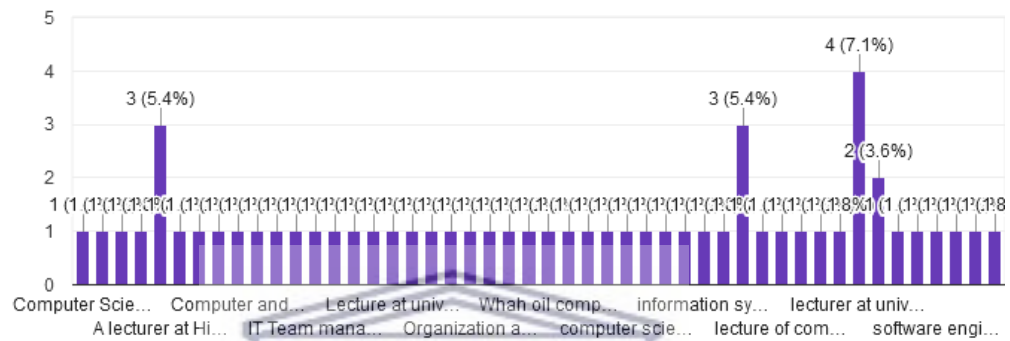
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Appendix H

QUESTIONNAIRE 3 RESULTS

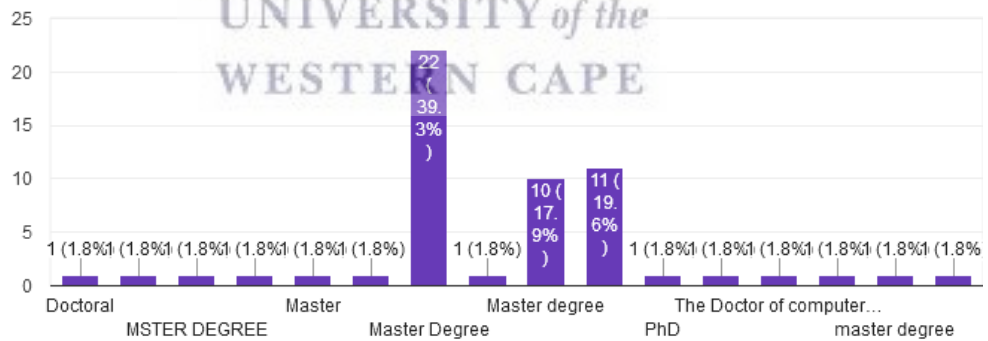
Occupation

56 responses



Qualification

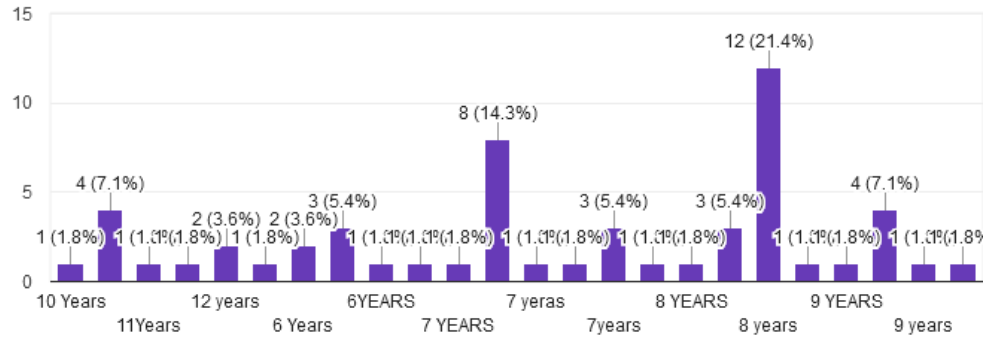
56 responses



Appendix H

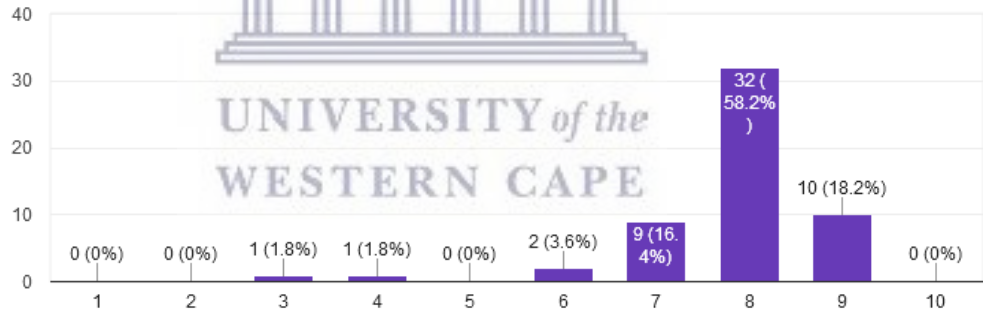
No of years worked

56 responses



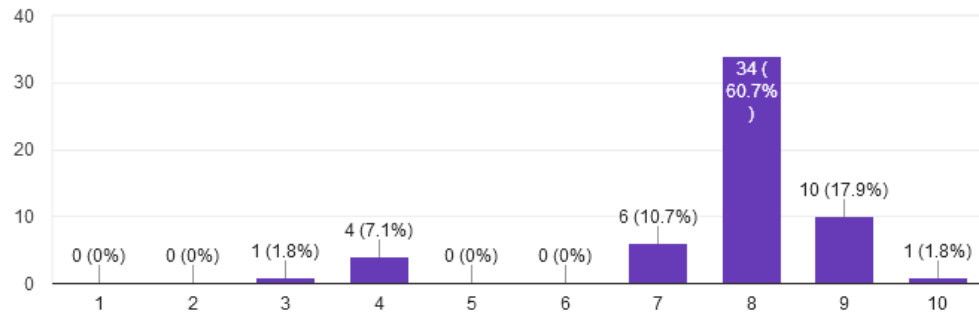
1- apply their knowledge (thus be technically savvy) and must not only have theoretical knowledge

55 responses



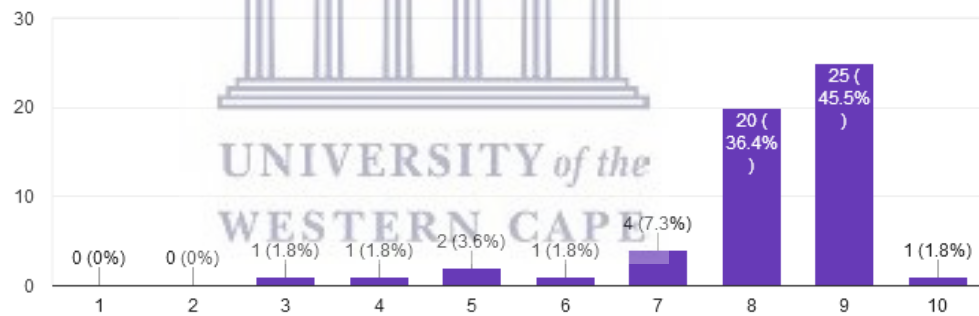
2-logically analyse a problem

56 responses



3- act ethical and professionally responsible

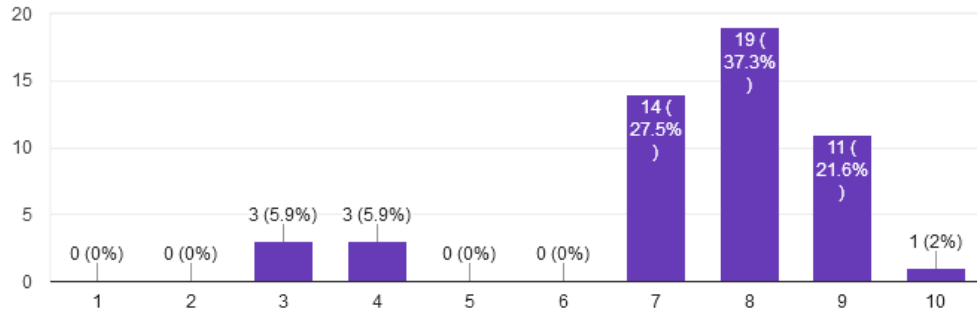
55 responses



Appendix H

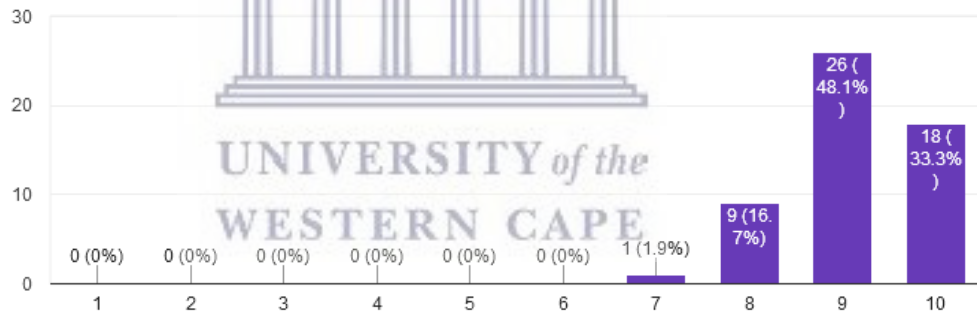
4-communicate well with peers and seniors

51 responses



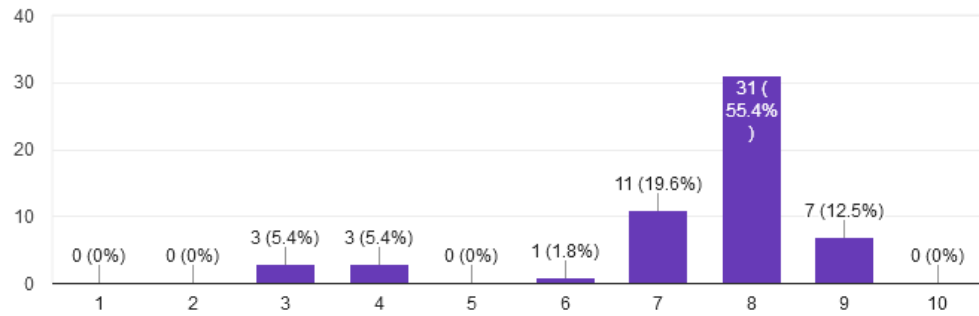
5-work successfully as a member of a team

54 responses



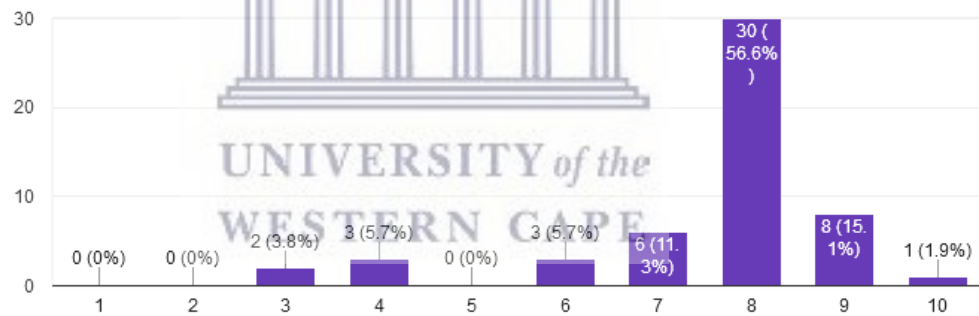
6-manage a project

56 responses



7-manage ambiguity and complexity in assigned tasks

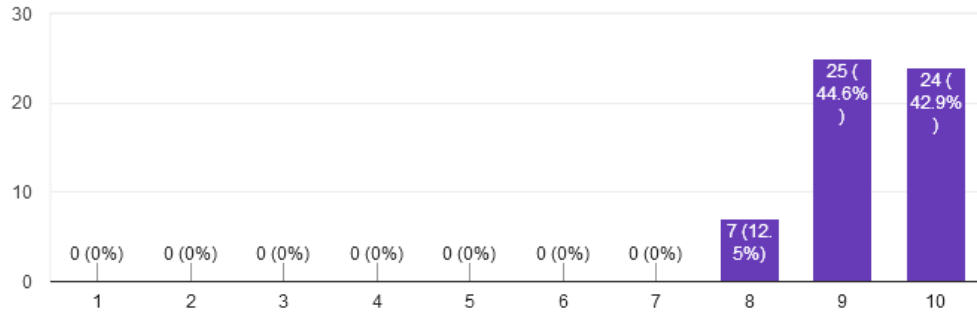
53 responses



Appendix H

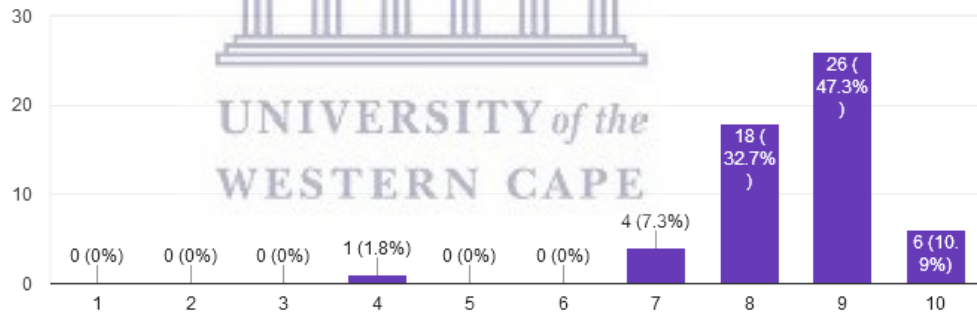
8-program and should have the necessary programming skills

56 responses



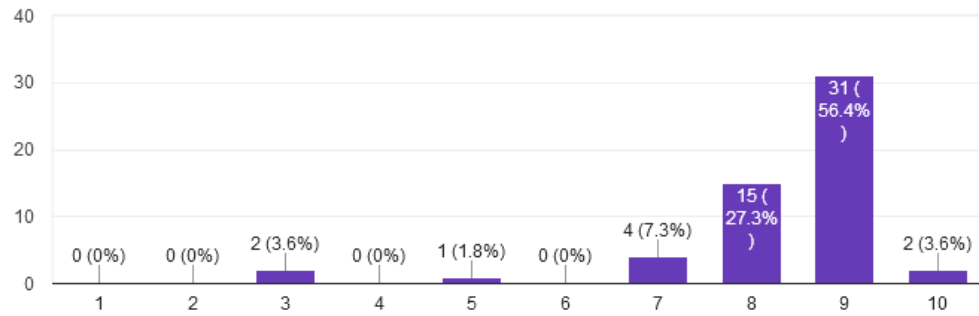
9-Graduates must be prepared to learn throughout their careers in order to be at the cutting edge of technology

55 responses



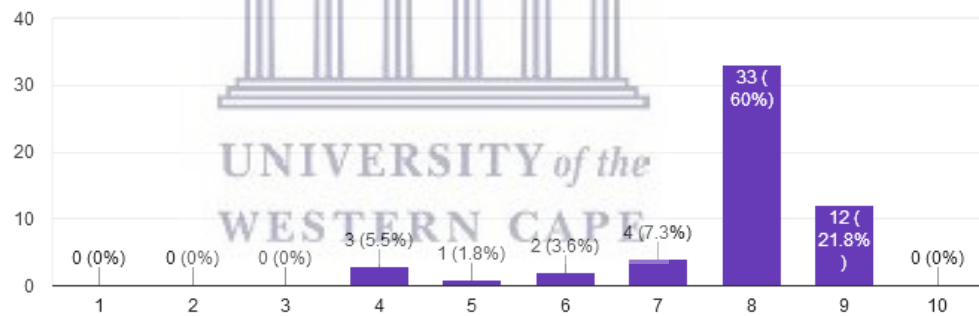
10-Graduates must have a critical attitude towards knowledge

55 responses



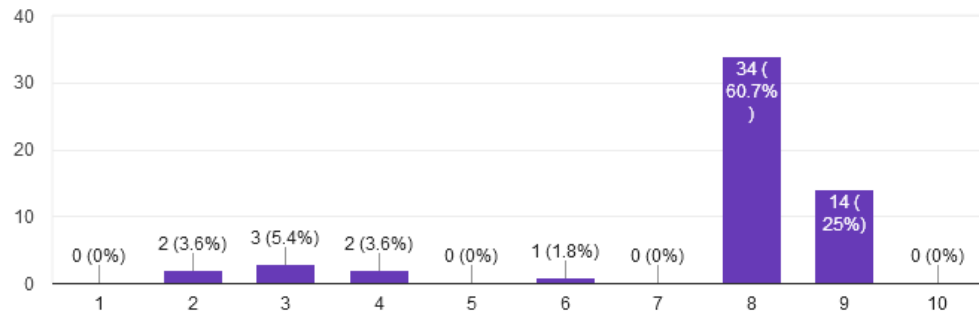
11-Graduates must have integrity and be honest

55 responses



12-Graduates must have an appreciation for business aware and its application

56 responses



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Appendix I

INTERVIEW PROBES

Interview probes	Research Question
1. What is your current position?	
2. How long have you been in this position?	
3. Why did you choose this career?	
4. What responsibilities do you have in your current position?	
5. What type of degree in Computer Science should an employee in your company have to be successful?	
6. What skills have you acquired at university which you feel stood you in good stead in your position?	1 nd research question
7. What skills have you acquired whilst working at this institution?	1 nd research question
8. What skills do you feel are needed for your position which you feel you did not have?	2 nd research question
9. How do you think your college/university education could address these skills more effectively?	2 nd research question
10. What graduate attribute has contributed most to your accomplishments in this company?	1 nd research question
11. Describe a situation where you worked with a team?	2 nd research question
12. How would you evaluate your ability to deal with conflict?	2 nd research question
13. Describe a situation where you felt you had not communicated well.	2 nd research question
14. How did you correct this situation?	2 nd research question
15. What courses/subjects that can be added into the existing curriculum to help in doing your job?	1 nd research question
16. Who do you feel that responsible for curriculum development?	1 nd research question
17. How do you think industry could do more to promote curriculum development?	2 nd research question
18. How do you think government should do more to promote curriculum development?	1 nd research question

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INTERVIEW RESULTS

Interview probes	Research Question	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5
1. What is your current position?		assistant network engineer	I am technical computer engineering and my position as assistance engineering	I am currently Computer Engineering	I am computing engineering and my position as assistance engineering	I am assistance computing engineering
2. How long have you been in this position?		I have been in this position 4 years	more than 3 years	I have been in this position about two years	2 years	2 years
3. Why did you choose this career?		My career path was chosen based on what I love and what I'm passionate about. I don't have a specific career destination when I was child.	I have chosen this career because it is related to my field	Because it was my first hope to work in logistics and also it's an interesting job.	I have chosen this career because it is related to my field	Because I am interesting and related to my field
4. What responsibilities do you have in your current position?		Our goal in company is to ensure the integrity of high availability network infrastructure to provide maximum performance for their users. Users may be	Well, My responsibility is to install and implement some computer project and also maintain and integrate some software. for example, I	There are several responsibilities I usually do like: 1- Installing new software to help us do jobs more easily.	My responsibility is update some software and install some networking. Such Internet connection and fix	Installation some software and fix some basic networking connection

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Interview probes	Research Question	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5
		staff, clients, customers and suppliers.	maintain some networks and fix some Internet connection	2- Fixing network faults.	some error	

5. What type of degree in Computer Science should an employee in your company have to be successful?		diploma software engineering would be optimal candidate for our company	Well, Depends on subject that you studied but bachelor degree is more succeed because they studied more courses at university.	The computer degree in this job is essential, so as high qualifications as the employees have are better, I believe the less degree an employee should have is high diploma.	Most company looks for the one who got experience but more subject have you study more better it means if you have got Master degree better than bachelor and so on .	Bachelor technical computing engineering
6. What skills have you acquired at university which you feel stood you in good stead in your position?	1	solving maths problems and basic programming skills	I think some technical computer skills such as Microsoft Word, Excel web application, maintains and fix some basic networking issue. also English language skills is very important	Actually there are many such as Microsoft Office, Delphi 5, and Java.	Some software such as web application, java script and multi-media such as Using computer-to locate, access, evaluate, store and recover information and to express ideas and communicate with others	I have got some skills that helped me for example Microsoft office and some software like Mat lab, Dreamweaver. Moreover, some basic networking course

<p>7. What skills have you acquired whilst working at this institution?</p>	<p>1</p>	<p>communication skills when working in a team</p>	<p>Well, I have gained some communication skills because I interacted and deal with the teamwork. Moreover I acquired some skills such as develop some web application, install some networking and analysis some security issue</p>	<p>During my working experience especially with my team work as following: 1- The Communications skills. 2- Networking. 3- Discussing solving problems.</p>	<p>I acquired some skills such as work with team and I learn how deal with some real issues such as fix some networks error and I have learnt to deal with different operating system such as Mac, Linux and Unix</p>	<p>Communication skills , networking solving and website designed</p>
<p>8. What skills do you feel are needed for your position which you feel you did not have?</p>	<p>2</p>	<p>when i started with the company the most skills I need to improve, was programming skills in computer tools such as open</p>	<p>the important skills which I need it's how to deal with team worker and how to communicate and interact with them and also I need more skills about developing and analysis some networking issue and developing web application</p>	<p>Maintaining computers and more networking skills</p>	<p>I need some skills in different operating system and some skills about web application for example how use GUI and made some website the other thing also important is how to solve some networking security issues</p>	<p>Solve and install networking issue designing some website using GUI and maintenance some computing hardware</p>
<p>9. How do you think your college/university education could</p>	<p>2</p>	<p>to put more effort to obtaining industry-standard , such as</p>	<p>I think college or university should develop their curriculum</p>	<p>1- University should keep curriculum up to date.</p>	<p>College must deal with company and see what the</p>	<p>College should improve and keep curriculum up to date ,</p>

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address these skills more effectively?		Cisco, HP, and others and improve the curriculum and keep up to date.	and keep it up to date. University should concentrate on technical skills more than theoretical and also university should make collaboration with some companies so students and staffs can learn and gain some skills by meeting some experts and employees.	2- University should concentrate in technician skills more than theoretical.	work place need for instance collage can update their curriculum. Collage also should teach students technical skills more than theory	in addition , collage can train teacher to be more effectively for example sent them overseas or take significant course also collage should fox on technical side
10. What graduate attribute has contributed most to your accomplishments in this company?	1	in any company, it need to hire fresh graduates as always they bring with them new ideas.	Well, depends on person itself some of them done some good job such as implement and maintain some technical issue.	There are many things were done by graduates like contributing in projects and have jobs done smoothly.	Some graduate did some good job such as did some website and some of them did and implement some project so they contributed the company	They did some contribution such as solve some software problem and some of them work with team effectively
11. Describe a situation where you worked with a team?	2 nd	In my current job, I work as part of a team, processing orders received and liaising directly with all departments in our company resolve any	When I am working as part of the team I try to be patient and provide my own idea and also I gained a lot of skills while the team around.	During my working with teams a lot of communication skills was earned. Teamwork makes the dream works. Alone I can do it together	It is important to working with team so I have got a lot of skills just it needs to be patient then will obtained a lot of skills	Work with team very important but you have to be carefully because I have to share idea to solve some problem and also do not blame anyone if

		<p>problems or queries in the company network. While administration forms the majority of the workload, there's also a lot of customer contact. Recently, my manager took the decision to resolve any problems not as individual which I had no problems to deal with as am good listener to the other member in our team.</p>		<p>we can do so much.</p>		<p>anyone mad mistake or sometimes had poor communication. working as part of group will earn a lot of skills</p>
<p>12. How would you evaluate your ability to deal with conflict?</p>	<p>2nd research question</p>	<p>I'd say am very good learner and very quickly to deal with any problems as they risen, of course with some help from the members of the team</p>	<p>Well, I am so patient with some conflict and I try to learn from the conflict. Sometimes I listen and learn from people who have good deal with problem.</p>	<p>Dealing with conflict is something not easy sometimes. Tracing up issue is the first thing should have done to know how to be solved. going back to the installation manuals can lead to the right solving process</p>	<p>I try to solve the conflict if it is easy otherwise I ask some employer to help so I always learn from others</p>	<p>Just I take it easy and then think carefully before deal with conflict or sometimes ask to help if it is big issue</p>
<p>13. Describe a situation where you</p>	<p>2nd research</p>	<p>Last year we had a new team</p>	<p>It was while working with the team and</p>	<p>I tried to solve some issues with</p>	<p>It was working to solve</p>	<p>I did some backup data but I</p>

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	felt you had not communicated well.	2 nd research	member who it was obvious from the start that he was clearly struggling with the administrative side of things so as I step up to help him, I did not deal with the situation very well	I try to give my opinion about some problem issue but some of them misunderstood.	no going back to the system administrator where all the data was about to lose completely	some networking connection but I did not sort out	lost some of them and then tried to sort out but I felt I had not communicated well
14.	How did you correct this situation?	2 nd research question	so with help with manager all the air is cleared afterword.	I tried to be more confident and revision my opinion then I fix the situation by meeting each one face to face and then I solved it	I imperially called for a meeting and discuss that issue in order to have a backup system in the future.	I try to solved by myself but it was too hard and complexed then I have sort out by asking some employer	There was copy of backup data so I solved smoothly
15.	What courses/subjects that can be added into the existing curriculum to help in doing your job?	1 nd research question	Most needed course are software programming language such as C++ and Java.	I think the more important courses are software development such as C++ and java, web design applications in addition there are some important courses for example, networking and security issue.	Networking security, Java script web design applications	It is important to add some different operating system such as Mac , Linux and Unix. Moreover , it should add some networking issues and web application	Difference software such as C++ JAVA and how to use GUI in different environment , learning different operating system like UNIX , LINUX
16.	Who do you feel that responsible for curriculum development ?	1 nd research question	Minister of higher education and university staff have some of the	The ministry of high education is the first responsible for curriculum	Country government, high education ministry, and	I think the government is responsible for curriculum	Collage and ,government should be responsible for

		responsible to update the curriculum.	development. Moreover, staffs at collage should keep the curriculum up-to-date because the Computer Science technology changed rapidly.	researches centre.	development also staff should keep the curriculum up-to-date	curriculum and keep it up to date also teachers have some responsibility
17. How do you think industry could do more to promote curriculum development ?	2 nd research question	every student should have option of the last year as placement year in industry place	the industry can promote curriculum development by training some students and staffs such as experts can give some advice to the staffs. In addition, industry should collaboration with college and university to keep staffs and student meets their new knowledge.	I believe this should be done by training students after and before their graduation and train the trainers.	By training some staff and students It can also invite staff and students to do some Worksop and conference so they can keep their knowledge and update their mind	I think industry should make leadership with collage so teachers and student can train more effectively
18. How do you think government should do more to promote curriculum development ?	1 nd research question	As the world now as small town thanks to the Internet, the government should ask for help from the countries which have very good standard education system and UN.	Yes , it can by keeping curriculum up-to-date and compare exiting curriculum with international standard .In addition, government should provide university with computers and free	Government should keep curriculum up to date and to be matches with the international standards. Government should provide universities by free Internet access and	By keeping curriculum up to date and follow the stranded curriculum and also government can sent or do some conference about curriculum	I think government can developing curriculum by comparing exiting curriculum with standard and also by train teachers to follow the last computing

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			access Internet and also it can sent some staffs and students overseas to gain more new knowledge.	make the staff up dated by sending them to for overseas courses.	development so it will be keep it up-to-date	development
--	--	--	--	--	--	-------------



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Appendix K

PROTOTYPE QUESTIONNAIRE

Name of Participant -----

Occupation-----

Email address-----

Please keep these in mind when evaluating the prototype.

Please rate your answer from 1 to 5, where 1 indicates *Strongly agree* and 5 indicates *Strongly disagree*.

Task list

Task 1

- 1.1 As Administrator of the University of the Western Cape's curriculum calculator system, your login details are: Username **halaiat**, Password **74962**
- 1.2 Please login.
- 1.3 Browse around a bit, you can for example view the modules as prescribed by the ACM.
- 1.4 Also view the courses for the BSc Degree that have been already been entered in the system.
- 1.5.1 Please add the following new course to the system:
 - University name: University of the Western Cape
 - Faculty name Natural Sciences

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- Department name: Computer Science
- Course name: Computer Science 255
- Course code: COS255
- Year level: 2
- How many Weeks is this course: 7
- Lecture hours per week : 3
- Tutorial hours per week : 1
- Practical hours per week: 3
- Modules to this course: 2

Once the task is completed, press the “**Add Course**”-button

1.5.2 Add two modules to course COS255 namely: Fundamental Concepts and Information systems just enter “xxx” for the description of the module.

1.5.3 Once the task is completed, **submit** the modules

1.6 You can update the course duration, lecture hours, tutorial hours and practical hours that already exist

1.7 You can delete a university course—this will also delete the modules of the particular course.

1.8 You can view all the entered course modules per programme

1.9 You may now also view all the registered users.

1.10 Add two new users (a Lecturer and a Guest) to the system. For each of these new users, complete the registration form, with a name and add your own e-mail address as the designated e-mail of the user. The information will be verified via email (thus you can check if the e-mail was sent or not).

How did you experience Task 1?

- It was easy to complete the task 1-5
- Was it useful to see how the programme compares with the ACM knowledge area 1-5
- Was the feedback appropriate for each step 1-5
- Was data correctly updated on the system? 1-5
- The functionality of the system was satisfactory 1-5
- All the added information was displayed correctly 1-5

Logout as the Administrator

Task 2

2.1 Login as the Lecturer you added in 1.10

2.2 Browse around a bit.

2.3.1 Use the ACM Curriculum Calculator tab and select the course code COS1521.

2.3.2 To calculate the ACM knowledge information for this course, it is necessary to specify the topics that are taught and how many hours of lecture time is used for each subsection.

For example, in this course (which constitutes two modules: Fundamental Concepts and Information Systems) some hours may be devoted to teaching Computer Security (IAS), Algorithms and Complexity (AL), Discrete Structures (DS) etc.

Please use the hours as shown in Table 1 to upload the teaching hours of COS1521.

Appendix K

Module name	Fundamental Concepts	Information Systems
Algorithms and Complexity	0	0
Architecture and Organization	0	0
Computational Science	1	4
Discrete Structures	0	0
Graphics and Visualization	1	0
Human Computer Interaction	0	0
Information Assurance and Security	0	0
Information Management	0	0
Intelligent Systems	0	0
Networking and Communication	0	0
Operating Systems	0	0
Platform Based Development	5	0
Parallel and Distributed Computing	0	0
Programming Language	4	0
Software Development Fundamentals	0	0
Software Engineering	0	0
Systems Fundamentals	0	0
Social Issues and Professional Practice	0	0

2.3.3 Consider how the programme compares to what the ACM suggests.

2.4 You may now also view the ACM course calculation. It shows you all the ACM curriculum calculation per university course.

2.5 View graduate attributes per degree. It shows you the characteristic of graduate attribute which are recommended by ACM IEEE and should be attained at least at an elementary level of graduate of Computer Science programs.

2.6.1 Add the degree BSc (Computer Science)

2.6.2 Add a 1— where 1 indicates it is important and 0 that is not —to indicate that an attribute is important for the BSC degree course.

Attributes:

Communicate well with peers and seniors,

Work successfully as a member of a team and

Have the necessary programming skills.

How did you experience Task 2?

The layout of text, graphics and links were user friendly 1-5

It was easy to understand what action each tool will perform 1-5

It was useful to calculate your course compare with ACM knowledge area 1-5

Did the feedback include what you need 1-5

The system has all functions that I expected 1,5

General comments on Task 2:

Logout as Lecturer

Task 3

You are now the Guest (that was added in 1.10), please login.

3.1 View the ACM modules

3.2 View all university courses

Appendix K

3.3 View all course modules per course.

3.4 View Course/ACM Calculations.

3.5 View Graduate Attributes per Degree

How did you experience Task 3?

- The system has all functions that I expected 1-5
- The speed of response to actions performed is suitable 1-5
- The information was clear 1-5
- The tutorial is logical and understandable 1-5



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Appendix L

EXPERT REVIEW RESULTS

How did you experience Task 1?

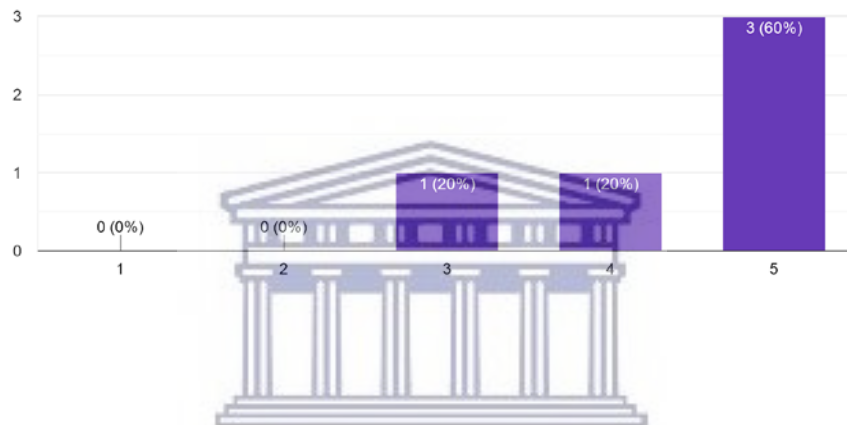
2 responses

Moderate

it was very useful and easy to use

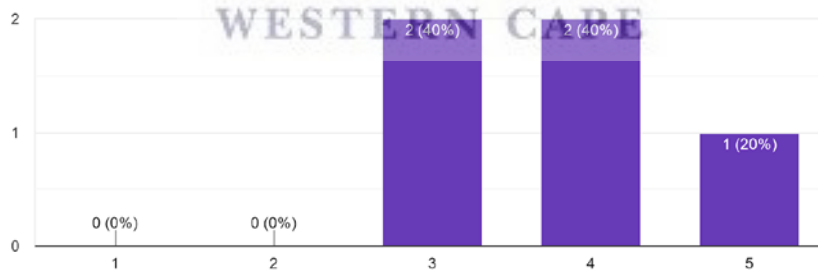
It was easy to complete the task.

5 responses



Was the feedback appropriate for each step?

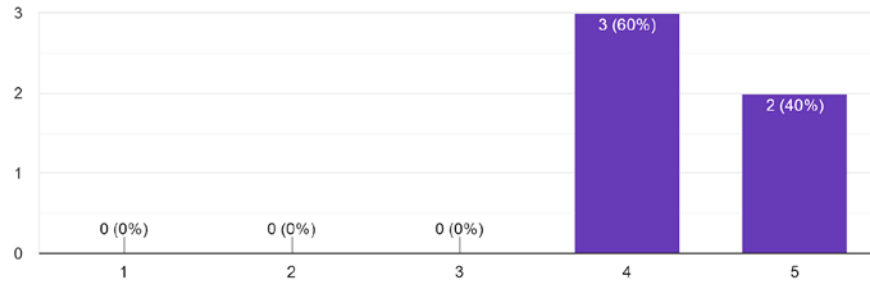
5 responses



Appendix L

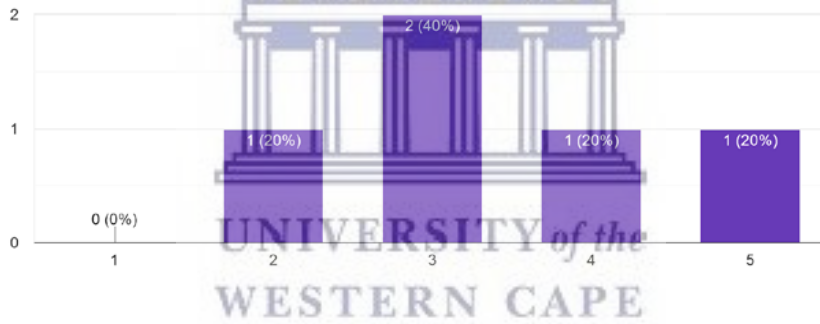
Was data correctly updated on the system?

5 responses



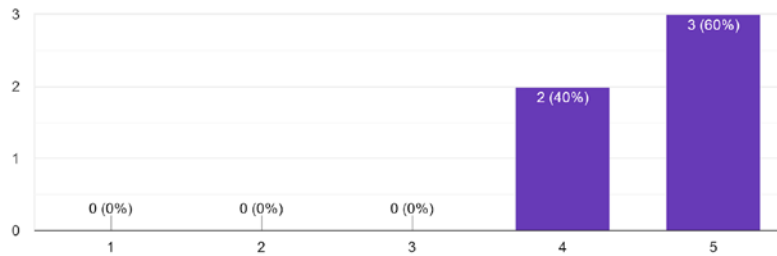
The functionality of the system was satisfactory.

5 responses



All the added information was displayed correctly.

5 responses



How did you experience Task 2?

3 responses

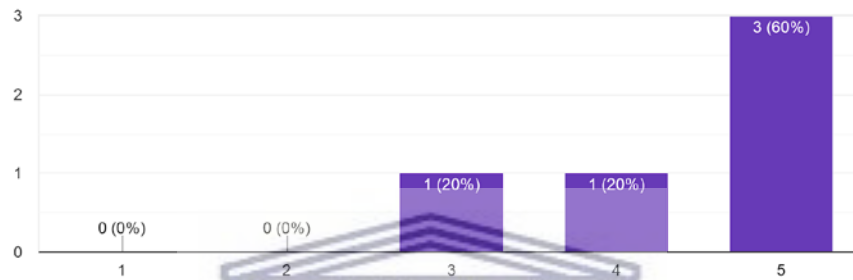
Moderate

It is a good idea to use this prototype to know how we are so far from ACM

It is need more clear information about how the programme compares the modules with to what the ACM suggests.

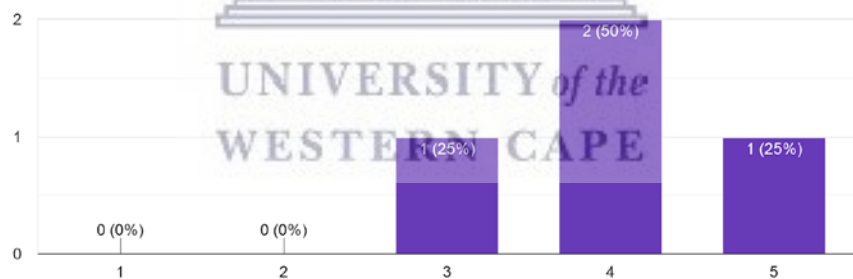
The layout of text, graphics and links were user friendly.

5 responses



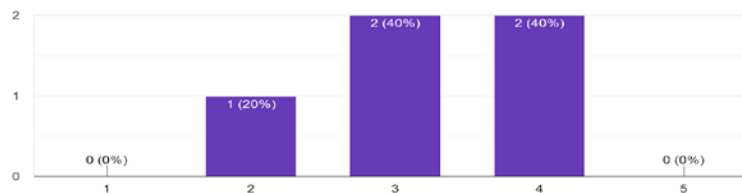
It was easy to understand what action each tools will perform.

4 responses



It was useful to calculate your courses compare with ACM knowledge area.

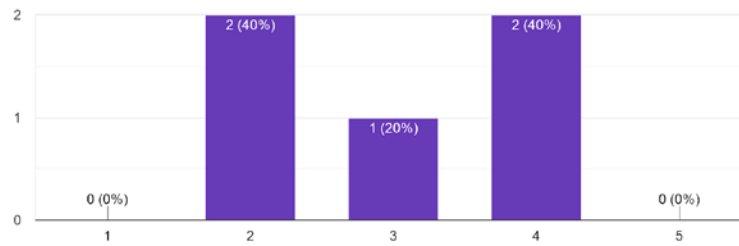
5 responses



Appendix L

Did the feedback include what you need?

5 responses



How did you experience Task 3?

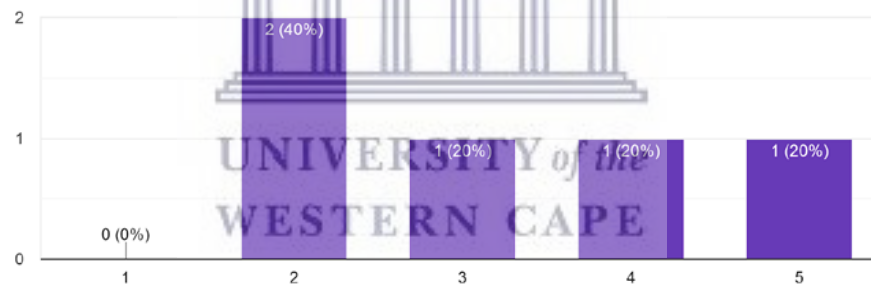
2 responses

Moderate

The user needs to be notified that the email has been sent to his/her address

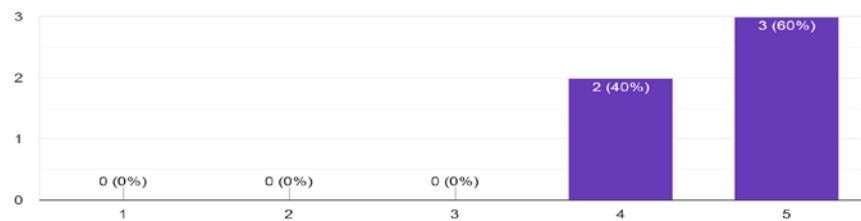
The system has all functions that I expected

5 responses



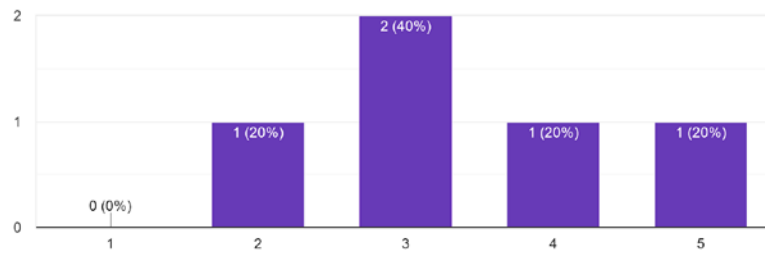
The speed of response to actions performed is suitable.

5 responses



The tutorial is logical and understandable.

5 responses



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BIBLIOGRAPHY

Bibliography

- Abuhadra, D. S., & Ajaali, T. T. (2014). *Labour Market And Emploment Policy In Libya*.
- Aithal, P. S., & Kumar, P. M. (2015). Enhancement of graduate attributes in higher education institutions through staged models. *International Journal of Research in Business Management*, 3(3), 121-130.
- Andreasson, K. (2015). *Digital Divides: The New Challenges and Opportunities of e-Inclusion*. (Kim J.Andreasson, Ed.) CRC Press.
- Asma, E., Mustafa, & Hussin, K. A. (2017). The Impact of Internet on Libyan Higher Education System: The Context of Cultural and Archaeological. *Journal of Communication and Computer*, 1-12.
- Asur, S., & Huberman, B. A. (2010). Predicting the future with social media. *In Proceedings of the 2010 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology. 1*, pp. 492-499. IEEE Computer Society.
- Bank, The World. (2017, November 18). *The World Bank*. Retrieved June 14, 2018, from <http://www.worldbank.org/en/country/libya/publication/economic-outlook-spring-2016>
- Beede, D. N., Julian, T. A., McKittrick, G., Khan, B., & Doms, M. E. (2011). *Women in STEM: A gender gap to innovation*. Washington DC: U.S. Department of Commerce.
- Bowen, G. (2009). Document analysis as a qualitative research method. *qualitative research journal*, 27-40.
- Budde, P. (2015). *Libya - Telecoms, Mobile and Broadband - Market Insights and Statistics*. Retrieved May 15, 2015, from <http://www.budde.com.au/Research/Libya-Telecoms-Mobile-and-Broadband-Market-Insights-and-Statistics.html?r=51>
- Burke, Q., & Kafai, Y. B. (2014). *Decade of game making for learning: From tools to communities*. *Handbook of digital games*.
- Business Wire. (2017). *Libya Telecoms, Mobile, and Broadband Statistics and Analyses 2017 - Research and Markets*. Retrieved June 29, 2019, from Business Wire: <https://www.businesswire.com/news/home/20170816005746/en/Libya-Telecoms-Mobile-Broadband-Statistics-Analyses-2017>
- Cackler, J., Gu, E., & Rodgers, M. (2008). *Technology in Developing Economies*. Retrieved May 16, 2015, from

Bibliography

- <http://cs.stanford.edu/people/eroberts/cs181/projects/developing-economies/>
- Check, J., & Schutt, R. K. (2011). *Research methods in education*. Sage Publications.
- Cooper, D., & Schindler, P. (2014). *Business Research methods*. McGraw hill international.
- Creswell, J. W. (2008). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (4th Edition ed.). Upper Saddle River, NJ: Pearson Education.
- Crotty, M. (1998). *The foundation of social research: meaning and perspective in the research process*. Sage.
- Denzin, N., & Lincoln, Y. (2000). *Handbook of qualitative research* (2 ed.). Thousand Oaks, CA: Sage Publications.
- Desurvire, H., & Wiberg, C. (2009). Game usability heuristics (PLAY) for evaluating and designing better games: The next iteration. *Online Communities and Social Computing* (pp. 557-566). Berlin, Heidelberg: Springer.
- Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: the tailored design method*. John Wiley & Sons.
- Directory, U. (2015). *University Directory Worldwide*. Retrieved July 31, 20145, from <http://www.university-directory.eu/jredirect/100776/Computer+Engineering/program-courses/Bachelor-degrees/42/Omar+Al+Mukhtar+University/LY/3757/Computer+Engineering+%28Bachelor+of+Engineering%29>
- Economics, T. (2016, December 07). *Libya GDP Annual Growth Rate*. Retrieved from Trading economics: <https://tradingeconomics.com/libya/gdp-growth-annual>
- Ekpereka, I. N., & Chibuogwu, C. I. (2017, April 9). Computer Programming Competencies Required by Computer Education Graduates for Sustainable Employment. *Canadian Center of Science and Education*, 9, 109-114.
- Elzawi, A., Kenan, T., Wade, S., & Pislaru, C. (2013). Internet and emerging Information technologies in Libyan Universities into reduce Digital Divide. *2nd International Conference on Internet , E-Learning & Education Technologies*, 12, pp. 44-50. Huddersfield.
- Freedom House. (2016, May). *Freedom On The Net*. Retrieved September 17, 2018, from Justice.gov: <https://www.justice.gov/eoir/page/file/916901/download>

- Freedomhouse. (2017). *Libya Country Profile*. Retrieved from Freedom on the Net 2017: <https://freedomhouse.org/report/freedom-net/2017/libya>
- Gelvanovska, N., Rogy, M., & Rossotto, C. M. (2014). *Broadband Networks in the Middle East and North Africa Carlo Maria Rossotto*. Washington.
- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British dental journal* 204, 291-295.
- Graduate Attributes*. (2014). Retrieved March 22, 2017, from Graduate Attributes and the Strategic Plan for Teaching and Learning: <https://www.uwc.ac.za/TandL/Pages/Graduate-Attributes.aspx>
- Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS quarterly* 37(2), 337-355.
- Gregory, R. W. (2011). Design science research and the grounded theory method: characteristics, differences, and complementary uses. *Theory-guided modeling and empiricism in information systems research*, 111-127.
- Guzdial, M., Ericson, B., McKlin, T., & Engelman, S. (2012). A statewide survey on computing education pathways and influences: factors in broadening participation in computing. *n Proceedings of the ninth annual international conference on International computing education research* (pp. 143-150). USA: ACM.
- Habermas, J. (1970). *Knowledge and interest in sociological theory and philosophical analysis*. Palgrave Macmillan.
- Hanton, P. B. (2015). *The Lack of Women in Technology: The Role Culture and Sexism Play*. Charles Town, WV: American Military University .
- Hartmann, T., & Klimmt, C. (2006). Gender and computer games: Exploring females' dislikes. *Journal of Computer-Mediated Communication*, 11(4), 910-931.
- Havenga, M., Breed, B., & Mentz, E. (2013). Metacognitive and problem-solving skills to promote self-directed learning in computer programming: teachers' experiences. *SA-eDUC*.
- Hayes, E. (2008). Girls, gaming and trajectories of IT expertise. In *Beyond Barbie and Mortal Kombat: New perspectives on gender and computer games* (pp. 138-194.).
- Hbaci, I. A. (2018, August). *Evaluating Educators' Competency in the Use of Computer Technology Toward Integrating Technology into Libyan Higher Education*. Retrieved November 1, 2019, from <https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=7&cad=rja&uact=8&ved=2ahUKEwjZsPOvrs7lAhWeSBUIHZ9>

Bibliography

- PAbgQFjAGegQIAxAC&url=https%3A%2F%2Fpdfs.semanticscholar.org%2F9078%2F9d37d10a7dc8cf3c16afde0691cf0d054dcd.pdf&usg=AOvVaw2Gf-Od0Mp6fcDF9bd-gMm
- Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004, March). Design Science In Information Systems Research. (I. L. S, Ed.) *Design Science in Is Research*, 28, pp. 75-105.
- Hewner, M. (2012). *Student conceptions about the field of computer science*. Georgia: School of Interactive Computing Georgia Institute of Technology.
- IEEE. (2013). *Curriculum Guidelines for Undergraduate Degree Programs*. Association for Computing Machinery (ACM).
- Impes, A., Othman, A., Wilson, D., & Pislaru, C. (2014). Analysis of Communication Barriers in Technical Vocational Education System in Libya. *International Conference on Communication, Media, Technology and Design*, (pp. 22 - 25). Istanbul.
- Internet World Stats. (2019, June 30). *Usage and population statistics*. Retrieved August 6, 2019, from Internet World Stats: <http://www.internetworldstats.com/stats.htm>
- Iwona Miliszewska , A. (2010). Towards E-Learning in Higher Education in Libya. *Issues in Informing Science and Information Technology*, 7, 424-434.
- Kafai, Y. B. (1996). *Gender Differences in Children\'s Constructions of Video Games*.
- Kafai, Y. B. (2006). Playing and making games for learning: Instructionist and constructionist perspectives for game studies. *Games and culture*, 1(1), 36-40.
- Ke, F. (2009). *A qualitative meta-analysis of computer games as learning tools. Handbook of research on effective electronic gaming in education* (Vol. 1).
- Kelley, Kate, & al, e. (2003). Good practice in the conduct and reporting of survey research. *International journal for quality in health care*, 261-266.
- Khail, D., & Halis, M. (2017). Challenges Facing the Quality of Education in the Libyan Higher Technical Colleges. *Imperial Journal of Interdisciplinary Research*, 13(10), 112-118.
- Kirdar, S. (2017). Education in the Arab World. In S. Kirdar (Ed.). Bloomsbury.
- Koeffel , C., Wolfgang, H., Leitner, J., Haller , M., Geven, A., & Tscheligi , M. (2010). Using heuristics to evaluate the overall user experience of video games and advanced interaction games. *In Evaluating user experience in games*, 233-256.

- Lenhart, A., Kahne, J., Middaugh, E., Macgill, A. R., Evans, C., & Vitak, J. (2008). Teens, Video Games, and Civics: Teens' Gaming Experiences Are Diverse and Include Significant Social Interaction and Civic Engagement. *Pew internet & American life project*.
- Leonard, K. (2018, June 29). *The Advantages of Being Computer Literate in the Workforce*. Retrieved 24, 2018, from chron: <http://smallbusiness.chron.com/advantages-being-computer-literate-workforce-27703.html>
- Lucero, A., Zuloaga, R., Mota, S., & Muñoz, F. (2006). Persuasive technologies in education: improving motivation to read and write for children. In *Persuasive Technology* (pp. 142-153.).
- Major Fields in Computing*. (2017). Retrieved April 8, 2017, from Itechcloud.blogspot.co.za: <http://itechcloud.blogspot.co.za/2011/01/major-fields-in-computing.html>
- Marshall, C., & Rossman, G. (2016). *Designing Qualitative research*. Massachusetts: Sage publications, Inc.
- Martin, P., & Barnard, A. (2013). The experience of women in male-dominated occupations: A constructivist grounded theory inquiry. *SA Journal of industrial psychology*, 01-12.
- Matinde, V. (2018, October 16). *It web africa*. Retrieved June 27, 2019, from Sub-Saharan Africa's smartphone penetration at 33%: <http://www.itwebafrica.com/mobilex/320-south-africa/244990-sub-saharan-africas-smartphone-penetration-at-33>
- Nelson, J. (2014). *Do You Think Mobile Gaming Will Ever Be Taken Seriously in the Minds of "Hardcore" Gamers?* touchArcade.
- Newmark, C. (2014, July 30). *Why It's Important to Get Girls Involved in Tech*. Retrieved September 15, 2017, from craigconnects: <http://craigconnects.org/2014/07/why-its-important-to-get-girls-involved-in-tech.html>
- Nieler, P. (2015, November 25). *Video Games Help You Improve Your Problem-Solving Skills*. Retrieved September 20, 2017, from LinkedIn: <https://www.linkedin.com/pulse/video-games-help-you-improve-your-problem-solving-skills-nieler>
- Nielsen, J. (1994, April 24). *World Leaders in Research-Based User Experience*. Retrieved June 26, 2019, from Nielsen Norman Group: <https://www.nngroup.com/articles/ten-usability-heuristics/>
- Nokut. (2017, April). *Refugees Country Briefing LIBYA*. Retrieved October 6, 2018, from Refugees and Recognition – Toolkit for recognition of higher education for refugees, displaced persons and persons in a refugee-like situation:

Bibliography

- https://www.nokut.no/contentassets/5751a837c39042b08776c0eacf416e41/country_briefing_libya_2017.pdf
- Nortvig, A. M., Petersen, A. K., & Balle, S. H. (2018). A Literature Review of the Factors Influencing E-Learning and Blended Learning in Relation to Learning Outcome, Student Satisfaction and Engagement. *The Electronic Journal of e-Learning*, 16(1), 46-55.
- Omicsonline.org. (2019). *The Higher Institute of Computer Technology*. Retrieved August 21, 2019, from OMICS International: https://www.omicsonline.org/universities/The_Higher_Institute_of_Computer_Technology/
- Oppenheim, & Abraham, N. (2000). *Questionnaire design, interviewing and attitude measurement*. Bloomsbury Publishing.
- Osunde, J., Windall, G., Bacon, P., & Mackinnon, P. (2014). Female Under-Representation in Computing Education and Industry - A Survey of Issues and Interventions. *IJACSA International Journal of Advanced Computer Science and Applications*, 5(10), 16-23.
- Othman, S., Kashadah, O., Gosbi, A. A.-G., & Khoja, S. (2012). *The higher education system in Libya*. Retrieved July 19, 2015, from http://eacea.ec.europa.eu/tempus/participating_countries/overview/libya_overview_of_hes_final.pdf
- Ouellette, A. (2017, September 20). *CareerFoundry*. Retrieved November 16, 2018, from What is Bootstrap: A Beginners Guide: <https://careerfoundry.com/en/blog/web-development/what-is-bootstrap-a-beginners-guide/>
- Overmars, M. (2004). Teaching computer science through game design. *Computer*, 37(4), 81-83.
- Passey, D. (2017, March). Computer science (CS) in the compulsory education curriculum: Implications for future research. 22(2), pp. 421-443.
- Pinelle, D., Wong, N., & Stach, T. (2008). Heuristic evaluation for games: usability principles for video game design. *SIGCHI Conference on Human Factors in Computing Systems* (pp. 1453-1462). ACM.
- Polsinelli, P. (2013, December 5). *Why is Unity so popular for videogame development?*. Retrieved July 2, 2018, from Design a game: <https://designagame.eu/2013/12/unity-popular-videogame-development/Thanks>
- Preece, J., Sharp, H., & Rogers, Y. (2015). *Interaction Design: Beyond Human-Computer Interaction* (4th ed.). John Wiley & Sons.
- Prottsman, C. L. (2011). *Computational thinking and women in computer science*. Oregon: Doctoral dissertation, University of Oregon.

- Rai, I. A., Rodrigues, A. J., Venter, I. M., Mills, G., Suleman, H., & Edumadze, J. (2013). Relevant Computing Curricula in Sub-Saharan Africa . In e.-I. a.-S. Countries, *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering series* (Vol. 119, pp. 239-248). Kampala.
- Rhema, A., Miliszewska, I., & Sztendur, E. (2013). Attitudes towards e-learning and satisfaction with technology among engineering students and instructors in Libya. *Informing Science Institute* (pp. 157-171). Victoria, Australia: Proceedings of Informing Science and Information Technology Education Conference.
- Roach, S., & Sahami, M. (2013, 4 1). *CS2013: Computer science curricula 2013*. Retrieved from <https://www.acm.org/education/CS2013-final-report.pdf>
- Rouse, M. (2015). *TechTarget*. Retrieved June 28, 2015, from <http://searchcio.techtarget.com/definition/ICT-information-and-communications-technology-or-technologies>
- Rouse, M. (2019). *Whatis.Com*. Retrieved June 17, 2019, from digital divide: <https://whatis.techtarget.com/definition/digital-divide>
- Sawahel, W. (2016, June). *Drastic measures needed to rebuild higher education – Report*. Retrieved July 28, 2019, from University World News: <https://www.universityworldnews.com/post.php?story=20160614131156211>
- School Computer Science. (2017, September 21). *Graduate Attributes | ECS | Victoria University of Wellington*. Retrieved September 17, 2018, from [Ecs.victoria.ac.nz](http://ecs.victoria.ac.nz): <https://ecs.victoria.ac.nz/Main/GraduateAttributes>
- Scragg, G., & Smith, J. (1998). A study of barriers to women in undergraduate computer science. *98 Proceedings of the twenty-ninth SIGCSE technical symposium on Computer science education* (pp. 82-86). Atlanta: ACM.
- Services, U. D. (2018, 4 8). *Usability.gov*. Retrieved from <https://www.usability.gov/how-to-and-tools/methods/prototyping.html>
- Shade, K. O., O, A., & Samuel , O. O. (2012, April). ICT: An Effective Tool in Human Development. *International Journal of Humanities and Social Science*, 2, 157-162.
- Simon C, & Barrie. (2004, August). A research-based approach to generic graduate attributes policy. *Higher Education Research & Development*, 23(3), 261-275.
- Smith, A. (2015). *U.S. smart phone Use in 2015*.

Bibliography

- Song, S. (2019). *Many Possibilities*. Retrieved November 4, 2019, from African Undersea Cables: <https://manypossibilities.net/african-undersea-cables/>
- Spikol, D., & Milrad, M. (2008). Physical activities and playful learning using mobile games. *Research and Practice in Technology Enhanced Learning*, 3(3), 275-295.
- Steen, F. F., Greenfield, P. M., Davies, M. S., Tynes, B., Vorderer, P. E., & Bryant, J. E. (2006). What went wrong with The Sims Online: Cultural learning and barriers to identification in a massively multiplayer online role-playing game. *Playing video games: Motives, responses, and consequences*, 307-324.
- Suchman, Lucy, Randall, T., & Jeanette, B. (2002). Working artefacts: ethnomethods of the prototype. *British journal of sociology*, 163-179.
- Suleman, Q., Hussain, s., Naseer Ud Din, M., & Iqbal, K. (2017). Effects of Computer-Assisted Instruction (CAI) on Students' Academic Achievement in Physics at Secondary Level. *Computer Engineering and Intelligent Systems*, 8, 9-17.
- Suppess, P. M. (2014). *Computer-assisted instruction at Stanford*. Academic Press.
- Tamtam, A., Gallagher, F., Olabi, A., & Naher, S. (2011, December 17). Higher education in Libya, system under stress. *Procedia - Social and Behavioral Sciences*, 29, pp. 742-751.
- The Association for Computing Machinery (ACM). (2005). *Computing Curricula 2005 The Overview Report covering undergraduate degree programs in Computer Engineering Computer Science Information Systems Information Technology Software Engineering*. USA: ACM IEEE Computer Society.
- The University of Sydney School of Education and Social Work. (2018, January 11). Retrieved September 17, 2018, from The University of Sydney : http://sydney.edu.au/business/__data/assets/pdf_file/0005/88385/Gra duate_Attributes_at_The_University_of_Sydney.pdf
- The World Bank. (2016, 05 17). *World Development Report 2016: Digital Dividends*. Retrieved August 15, 2018, from The World Bank: <https://www.worldbank.org/en/publication/wdr2016>
- The World Bank. (2018, June 30). *Middle East and North Africa*. Retrieved August 06, 2019, from The World Bank : <https://www.worldbank.org/en/region/mena>
- Triki, N. M. (2016, December). Innovations and Curriculum Development for Technical and Engineering Education in Libya. *Literacy Information and Computer Education Journal*, 7(4).

- UNDP. (2016). *Human development for everyone: Briefing note for countries on the 2016 Human Development Report - Libya*. UNDP.
- Vaishnavi, V., & Kuechler, W. (2012, November 11). *Design Science Research in Information Systems*. Retrieved July 29, 2015, from <http://www.desrist.org/desrist/content/design-science-research-in-information-systems.pdf>
- Venter, I. M. (2000). Group constitution for small group learning in the field of information technology. *PhD thesis*. Pretoria, South Africa: Univeristy of Pretoria.
- Venter, I. M., de la Harpe, R., Poneelis, S., & Renaud, K. (2015). Deploying design science research in graduate computing studies in South Africa. *Twentieth Americas Conference on Information Systems* (pp. 1-11). Puerto Rico: AIS.
- Walker, M., Takayama, L., & Landay, J. (2002). High-fidelity or low-fidelity, paper or computer? choosing attributes when testing web prototypes. *Proceedings of the Human Factors and Ergonomics Society 46th annual meeting* (pp. 661-665). Baltimore, USA: HFES, Santa Monica.
- Werner, L. L., Hanks, B., & McDowell, C. (2004). Pair-programming helps female computer science students. *Journal on Educational Resources in Computing (JERIC)*, 4.
- Whetten, D. A. (1989). What Constitutes a Theoretical Contribution? *Academy of Management Review*, 14, 490-495.
- Zuboff, S. (1988). *In the Age of the Smart Machine: The Future of Work and Power*. Basic Books.
- Zyda, M. (2005). *From visual simulation to virtual reality to games*. *Computer*, 38(9), 25-32. USC Information Sciences Institute.