QUALIFICATION SPECIFICATION SECTION A								
QUALIFICATION DEVELOPER	Amistad Education Botswana							
TITLE	Bachelor of Science in Computer Science				**NCQF LEVEL**		7	
FIELD	Information and communication technology			**SUB-FIELD**	Computer Science			
New qualification	✓		Review of existing qualification					
SUB-FRAMEWORK	General Education		TVET		Higher Education	✓		
QUALIFICATION TYPE	Certificate		Diploma		Bachelor	✓		
	Bachelor Honours		Master		Doctor			
CREDIT VALUE	480							

RATIONALE AND PURPOSE OF THE QUALIFICATION

It is a truism that Computer Science and its allotropic modifications, which depend on the blends of other disciplines such as exact sciences (mathematics and physics), engineering and/or the ones from social, behavioral and economic/business provenience, such as information systems, human-computer interaction, and intelligent search that has had a more generative and transformative impact on the contemporary societies. In fact, the changes have been so profound on every sector of human activities, that today (1) all references to a societal dynamics are modelled to digital or information society, and (2) there is virtually no country, whether it is developed or an emerging one that has no national strategies about digitalization and information society as living and pragmatic instances of various computer science aggregations. For example, EU has a digital agenda that refers to all its members and one of the most important activities is the establishment of a single digital market. Indeed, the extent that computer science has affected the humanity and has become virtually mandatory for everyone to receive some form of computer education irrespective of the area they would like to pursue in a professional life. In some way, the world has evolved into a digitally dependent blend of computing oriented infrastructures and services, which most of time make a difference between functioning and non-functioning societies.

The proposed educational effort concerning the qualification is based on several fundamental paradigms such as a blend of theory and practice, system level perspective with a holistic flavor, problem-solving capabilities, learning by doing via projects both individual and group ones, openness to future learning, and commitment to professional and societal responsibility and integrity [21]. Those are built in axiomatically in the qualification proposed for BSc in Computer Science to be offered, which takes and builds on the similar qualification offered by Stockholm university, the oldest and the largest research and higher educational institution in computer and systems sciences in Sweden. Moreover, the qualification follows the ideas and principles set forth into the last version of the Computer Science Curricula 2013, prepared by the Joint Task Force from ACM and IEEE Computer Society and published in December 2013. They divide the qualification into eighteen different knowledge areas, which are distributed in three tiers [24].

This qualification recognizes that computer science is a fast-developing and constantly evolving conglomeration of disciplines with concepts and practices while present today, might be invalidated to a certain extent by tomorrow. Hence, the qualification identifies invariant ideas, concepts and theories, translated into a fundamental component, a core component, and specialization one. The fundamental

component includes introduction to computer science, logic and formal systems, discrete mathematics and structures, system foundations, programming, information processors and data bases, while some of the areas covered by core component are the art and the theory of programming, design of algorithms along with a computational complexity, non-kinetic mental presentations able to emulate human reasoning expressed via computational intelligence, and security and integrity of the computational systems, networking, and software engineering. The other areas are made from various electives that color the current interests of the students, the society and the job market. They include viable overtones towards the soft and socio-technical aspects of computing, while considering also that the shelf-life of some applied ICT knowledge is rather short.

Moreover, there has not been any other scientific and educational enterprise than the one based on Computer Science which has created more jobs based on a self-employment, small companies, and niche ventures (for example various start-ups and spin-offs where academia plays a dominant role), which is crucial for increasing opportunities on the job market for the young population.

Demand Driven and Market Oriented Approach

A large number of jobs in the region are becoming more intense in their use of digital technologies. The most benefits, both on a short-term and on a long-term, from ICT intensive jobs are likely to be in digital design, creation and engineering, rather than the lower-skilled delivery of digital products or services, for which it is essential to attain a university degree in Computer Science. Thus every higher education qualification in Computer Science should be vigilant and flexible to anticipate some of the market perturbations and react with the appropriate modifications in the curriculum[20].

Human Resource Development Council (HRDC), which was set up to provide policy advise, coordinate and promote development and implementation of the national HRD strategy, identified ICT and Computer Science included, among the Top 20 Priority programmes in need for Botswana [8].

A recent survey indicates that there is a need for Computer Science qualifications at all levels. A Bachelor's degree in Computer Science was one of the qualifications found to be in great demand [4]. The qualification actually reflects the findings presented in [8, 9], where the most relevant and demanded jobs concerning the ICT sector in Botswana are Database designers and administrators, Telecommunications Engineers, System Administrators, Computer Network Professionals, Application Programmers, System Analysts, Software Developers, Web and Multimedia Developers, Data Centre Managers, ICT Security Managers, and IT Service Managers.

All of the aforementioned arguments make the case for a rigorous, comprehensive and self-modifying BSc qualification in Computer Science along with various flavors of specialization. It is also based on a project oriented problem solving, as one of the ways to reinvigorate the ICT education and its propagation in many other areas, improve the employability by opening new market opportunities especially for young people [24]. This will be also facilitated by blended and in particular distance (on-line) mode of education, which will decrease cost, solve many logistic problems, and enable access to tertiary education in Computer Science to a wider audience and possibly become an ICT knowledge hub for the SAA region [23].

ENTRY REQUIREMENTS (including access and inclusion)

BGCSE/equivalent with a minimum of grade D in English Language, grade C in Mathematics and grades of C in any two from Physics, Biology, Chemistry, Computer Studies, OR a minimum of grade BB in Science Double Award OR a minimum of grade A in Physical Science and grade C in Biology or its equivalent. Candidates with extensive prior learning can also be admitted see section on RPL.The qualification will also admit graduates of Level 6 in the same field.

QUALIFICATION SPECIFICATION B	SECTION
GRADUATE PROFILE (LEARNING OUTCOMES)	**ASSESSMENT CRITERIA**
Valuate the substantial knowledge of the foundation theory of Computer Science and Mathematics and an understanding of current developments in the field.	**1.1** Foundation knowledge in computer science is explained and applied; 1.2 Current trends/developments in Computer Science are described and analysed; 1.3 Proficiency in mathematics for Computer Science 1.4 Describe and view the subject of computer science from a general system theory perspective. 1.5 Understand and describe project management in the Computer science context 1.6 Understand and apply database technology and support tools 1.7 Working knowledge of AI and machine learning and be able to apply theories and analyse related problems 1.8 Computer networks and associated technology and theory understood and applied 1.9 Computer and information security theory and methods applied and understood
Design, engineer and develop state-of-the art software systems using modern technology and methods	2.1 Software development methodology explained and applied; 2.2 Proficiency in software engineering and development shown; 2.3 The connection between software and hardware explained and shown; 2.4 UX design and human computer interaction explained and applied; 2.5 Proficiency in advanced software development including network programming and client/server side apps shown; 2.6 System utilities such as parsers, compilers, OS etc. understood and applied; 2.7 Ability to take an holistic system theoretical approach to software development shown 2.8 Theory around requirements engineering and benefit realization understood and applied 2.9 Object oriented paradigms applied and understood 2.10 Theory around hardware design and the interplay between hardware and software understood and applied

Apply Computer Science in a professional and ethical way as leaders of the computer science community.	3.1 Ethics in computer science described and discussed; 3.2 Professionalism understood and contextualized; 3.3 Computer science as a community and how to contribute understood and analysed
Carry out fundamental research and show readiness for graduate studies in the field.	4.1 Issues critically, autonomously and creatively identified and formulated. 4.2 Advanced tasks using appropriate methods within predetermined time frames are planned for and executed. 4.3 Contemporary problems, opportunities and future wants and needs that contribute to the development of the field of knowledge are appraised. 4.4 Effective oral and written presentations are made; 4.5 Own results and others viewpoints in a coherent and qualitative way are conveyed; 4.6 Own conclusions and the knowledge and argumentation which they are based on, in dialogue with different audiences in national and international contexts are discussed. 4.7 The possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used are discussed.

QUALIFICATION STRUCTURE SECTION C			
FUNDAMENTAL COMPONENT Subjects / Units / Modules /Courses	**Title**	**Level**	**Credits**
	Introduction to computer science	**7**	**15**
	Object oriented design and development	**7**	**15**
	Computer organization and architecture	**7**	**15**
	Data structures and algorithms	**7**	**15**
	Discrete mathematics	**7**	**15**
	Scientific writing	**7**	**15**
	Information security and assurance	**7**	**15**
	Bachelor thesis	**7**	**60**
CORE COMPONENT Subjects / Units / Modules /Courses	**Elements of Data Science**	**7**	**15**
	Fundamentals of software engineering	**7**	**15**
	Networks	**7**	**10**
	ICT project management	**7**	**10**
	Logic and formal systems	**7**	**10**
	Theory of programming	**7**	**15**
	Graph theory and combinatorics	**7**	**10**
	Database methodology and design	**7**	**10**
	Parallel and distributed programming	**7**	**10**
	Artificial Intelligence	**7**	**10**
	Machine Learning	**7**	**10**
	History of computing ideas	**7**	**10**
	Network design and management	**7**	**10**
	Network and cyber security	**7**	**10**
	Computability and algorithm complexity	**7**	**10**
	Abstract machines and automata	**7**	**10**
	Probability and statistics	**7**	**10**
	System utilities and tools	**7**	**10**
	Industry internship	**7**	**30**
ELECTIVE COMPONENT Subjects / Units / Modules /Courses	**Philosophy of computer science**	**7**	**15**
	Requirements engineering	**7**	**15**
	Linear and non-linear optimization	**7**	**15**
	Search and computational thinking	**7**	**15**
	Data Science	**7**	**15**
	System design and development	**7**	**15**
	Software security	**7**	**15**
	Software testing and verification	**7**	**15**
	Decision support systems	**7**	**15**
	Applied queueing theory	**7**	**15**
	Applied queueing theory	**7**	**15**
	Graph theory and combinatorics	**7**	**15**
Rules of combinations, Credit distribution (where applicable):			
Students must obtain a total of 480 NCQF credits in order to Graduate.			

Credit distribution is as follows (in order to graduate students must complete the following with a passing grade)
Total of a 165 credits from Fundamental components, this includes a 60 credit thesis.
Total of a 225 credits from Core components, this includes the industry internship
Total of a 90 credits from Elective components.

ASSESSMENT AND MODERATION ARRANGEMENTS

ASSESSMENT

Formative assessments will be done multiple times during a course to give our educators a feedback mechanism so that instructional approaches, teaching materials, and academic support can be modified accordingly and the teaching techniques and material can be improved. This gives naturally a good ground for the summative assessments of the learners' learning. The latter are the usual graded tests, assignments, or projects that are used to determine whether learners have accomplished the course or program goals. Performance assessments requiring learners to complete more complex tasks, such as writing assignments, science experiments, performances, or larger projects will also be performed. Collaboratively developed common assessments, authentic scoring guides, rubrics, and other methods to evaluate whether the work produced by learners shows that they have learned what they were expected to learn shall be used.

Portfolio-based assessments are another important assessment method to be used. Learners shall present collections of academic work that are compiled by learners and assessed by groups of educators in consistent ways. Various types of interim assessments to evaluate where learners are in their learning progress and determine whether they are on track to performing well on future assessments shall be used.

All Assessment shall be done by BQA registered Assessors for all the courses.

Internal moderation
All assessment instruments shall be internally moderated before administration by a colleague in the same field. The preparation of the moderation shall be accompanied by the Marking Key. Reports and associated documents include: Assessment Instrument, Marking key, Internal Moderation report and a List of candidates and scores attained. Internal moderation shall be done by BQA registered Moderators.

External moderation
External moderation shall be done by external subject experts to verify validity of the examination instruments before they are written by learners and taking a 10% sample of scripts after marking to verify that marking was at the right standard for the type and level of the qualification. External moderation may result in an adjustment of the allocated scores. Moderators used will be those registered by BQA.

GRADING

- There shall be at least 2 written tests and a written examination per course these should be summative in nature
- A letter grading system A-F shall be used. A-E are passing grades and F is a failing grade
- The Weightings between continuous assessment and final exam shall be on a 50% continuous assessment and 50% final examination.
- At least 50% of the course grade should be based on summative assessment

RECOGNITION OF PRIOR LEARNING (if applicable)

A clear framework through which students can accumulate learning credits and transfer such credits toward appropriate qualifications helps to validate and recognize learning gained through formal and informal means, provides flexibility to students, and allows students to progress relatively seamlessly through their lifelong learning journey.

Candidates may apply for recognition of prior learning whether such learning has been gained through formal study, through workplace learning, or through any other formal or informal means. Any candidate applying for recognition of prior learning (RPL) will be expected to provide evidence of such learning that must be relevant, sufficient, valid, verifiable, and authentic. In addition, the candidate may be interviewed by a member of staff or have to take a formal test, which may include a live demonstration of skills and competencies, to assess competence.

PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

Learning Pathways

Horizontal Articulation

Graduates from this qualification can go on to do related qualifications at the same level such as:

- BSc in Networking
- BSc in Computer Engineering
- BSc in Software Engineering
- BSc in Informatics

Vertical Articulation

Candidates who complete this qualification can go on to pursue:

- BSc with honors in similar fields
- MSc in Information Sciences
- MSc in Computer Science
- MSc in Information Management

Employment Pathways.

Graduates from this qualification can be employed as any of the following but not limited to:

- Software designers
- Programmers
- IT professionals and consultants
- System designers

QUALIFICATION AWARD AND CERTIFICATION

After completion of the qualification and a total of 480 NCQF credits students are awarded a Bachelor of Science In Computer Science

The requirements for successful completion are:

- Completed the required courses and selected electives with a passing grade
- Completed a thesis with a passing grade

When the qualification syllabus is rescinded, the student has the right to complete the education according to the present curriculum during a settlement period comprising the qualification's nominal

duration plus two years. During this period the limitations stated in the syllabi apply primarily regarding the courses included in the qualification, and secondarily equivalent courses are offered. A Degree of Bachelor In Computer Science is awarded after the student has completed the courses required, including a thesis. To write the thesis students should have completed the full first two years and ¼ of the credits from the third year. Candidates meeting prescribed requirements will be awarded the qualification in accordance with standards prescribed for the award of the qualification and applicable policies.

REGIONAL AND INTERNATIONAL COMPARABILITY

There are a respectable number of undergraduate qualifications in Computer Science at the higher-education institutions in Botswana, as enumerated in the below. As far as the regional institutions are concerned, we have selected three universities in South Africa such as University of Witwatersrand, University of Pretoria, and Stellenbosch University. Finally, for the international context, we have looked specifically in the qualifications offered by the three leading schools in the United States, Stanford University, Harvard University, and MIT, and one in Europe, namely Cambridge University in UK. Most of the knowledge areas covered by all of the higher education schools reflect the ones found in the ACM/IEEE GUIDE 2013 [30].

National Endeavors in Computer Science Higher Education in Botswana

Regional presence

There are arguably very good schools in the region of Sub-Saharan Africa offering qualification in computer science, with the most prominent ones in South Africa, where we focus to the four leading universities such as University of Pretoria, University of Witwatersrand, Stellenbosch University, and University of Cape Town. These universities, based on the traditional Computer Science qualification, offer variety of flavors that range from overtures to systems sciences (information systems) to engineering with stronger emphasis on computational infrastructures, and occasional excursions into business and economics.

University of Witwatersrand has a qualification in Computer Science where programming is present in most of the undergraduate courses combined with the principles of high-performance computing, mobile computing, artificial intelligence, and networking. They also allow infusion of advanced mathematical subjects applied to various aspects of the financial disciplines, as well as to computational aspects of applied mathematics [12].

University of Pretoria has excellent research facilities termed as Engineering, Built Environment and IT (EBIT), where some engineering directions are occasionally ranked among the top institutions in the world. The qualification in Computer Science, IT, and Informatics are an integral part of EBIT and it is the only degree in Africa internationally recognized by the Accreditation Board for Engineering and Technology of the USA. The freshman enrollment is about five hundred students which are distributed into three different profiles such as Information Science combined with Multimedia, Information Technology, and Computer Science. It is worth noting the Centre of Excellence for Information Ethics, a discipline that should be an integral part of every computer science qualification in the age of artificial intelligence and the emerging autonomy of artificial systems [10].

Department of Mathematical Sciences within the Faculty of Science at Stellenbosch University has three qualification divisions, one of which is computer science. While it is a fairly small qualification in a number

of students, the graduates have gained a solid reputation among the employers in the country due to their good programming skills and profound knowledge in the theory of computing. The qualification related to computer science is also followed by some electrical engineering students. There are opportunities to induce a qualification which is colored with statistics and operation research via the Faculty of Economic and Management Sciences or with the one that blends with the Department of Electric and Electronic Engineering. According to the Department, the entrepreneurship and innovation are central to their qualification agenda, which is also signified with some of the students applying and getting accepted in the graduate schools of Oxford University and CMU [9].

The science of information and computing has two qualification venues at the University of Cape Town, namely the Department of Information Systems and qualification in computer science within the Science Faculty. The qualification in Computer Science degree may lead to professional certification by the British Computer Society. There are joint efforts with the qualification in commerce, business sciences, and information sciences, where the part of computer science depends on the final qualification and the number of computing courses within the curriculum of each student [11].

Global outreach

Four schools have been selected to provide the global framework for the Amistad qualification in Computer Science based on a simple criterion of being among the top ten academic institutions in the world. In fact many of the ideas, concepts, areas, problems, innovations fundamental to Computer science qualifications were conceived in these academic institutions. There are a lot of similarities between Cambridge University, Stanford University, Harvard University, and MIT relative to their respective qualifications in Computer Science, where as expected the former three are inclined more to theoretical aspects and general science theories, while the later has some explicit engineering flavor.

At Cambridge university for the undergraduate qualification, there is a lot of emphasis on mathematics and physics, and one may even consider computer science as a major and mathematics and physics as a minor. The part that belongs to the computer science courses may vary between fifty and seventy-five percent in the qualification. Intensive lab work is expected, but in general the qualification provides a very comprehensive foundations in theoretical aspects of computer science as a relative of mathematics and natural sciences, with certain intrusions by the philosophy of computing [5].

Stanford University, while it has some more engineering than Cambridge, in a certain way continues along the same line of the qualification, to offer diversity and flexibility by requesting 26 units of math, 11 units of science, 13 units of engineering fundamentals, a course in technology in society, along with 43 units in core and in-depth computer science out of minimum of 96 units. The track structure of the CS qualification also allows to pursue the area(s) of CS one considers to be most interesting such as artificial intelligence, robotics, software design, graphics, theory, or hardware design. Stanford recognizes that there is an increasing demand for people trained in CS and its application to other areas, which implies an infusion of the other disciplines via electives and minor qualifications [6].

The profile of the undergraduate qualification in Computer Science at Harvard University, follows the traditional lines of both Cambridge University and Stanford University, with a strong emphasize on the mathematical, logic and philosophical foundations of computing, as well as the traditional disciplines such as algorithms, data structures, networks, operating systems, computer graphics, and computer architecture and organization. However, there is also a series of courses that reflect current developments such as computational linguistics, data science, robotics, and artificial intelligence. Interestingly enough, one of the first courses that is offered to the undergraduate students addresses

the great ideas in computer science. There is a set of courses in computing that students at Harvard University and MIT could mutually substitute. The most advanced topics included in the qualification that are also inclined towards research are given via selection of areas that reflect problem solving or theoretical reflections [7].

Massachusetts Institute of Technology, MIT, within the Department of Electrical Engineering and Computer Science offers a qualification in the later, where the fundamentals are central the spectrum of courses including computer programming, program constructions and development, computing infrastructures, data science, even signal processing and robotics modeling and engineering. As both theoretical and applied aspects of mathematics are seen as essential to thorough understanding of computer science, there are a number of courses that range from discrete mathematics to probability theory included in the qualification [8].

Conclusion: Obviously, there are excellent computer science qualifications both in the region and on the global arena, and it is very good for the future of Amistad to have some kind of twining cooperation via exchange of scholars and students, which will provide a fertile ground for improvements, updates and changes that will reflect the dynamic nature of the contemporary world. This is also consistent with AIM-Tech cooperation and collaboration with Stockholm university, However, we should not forget that one of the best ways to avoid “brain drain” is to have domestic well thought and comprehensive programmes that will attract the finest potential of the Botswana youth, where actually the whole country, including the private and the public sectors, will be “the living lab” for the qualification, and where the students from the very start of their education and qualification in Computer Science will see the future seeds of their professional careers and the road to their vocational fulfillment.

Finally, the qualification in Computer Science affords, inter alia, the status of an internationally recognized qualification, which also mirrors the criteria and the exposure of the Stockholm university that creates the necessary innovation and diffusion of various knowledge areas. Additionally, this gives rise to (1) competitive advantages, (2) inter-referential criteria, and (3) a possibility to increase the undergraduate enrolment which may decrease the intellectual drain of Botswana.

Comparative review	AEB	UoW	UP	SU	STU	MIT	CU	HU
Introduction to Computer Science	X	X	X	X	X	X	X	X
Science of Computing	X	X	X	X	X	X	X	X
Formal Systems in Computing	X	X	X	X	X	X	X	X
Mathematical Foundations of Computing	X	X	X	X	X	X	X	X
Intelligent Systems	X	X	X	X	X	X	X	X
Distributed and Parallel Computing	X	X	X	X	X	X	X	X
Research Theory, Strategies and Methodologies	X	X	X	X	X	X	X	X
Problem Solving Capabilities	X	X	X	X	X		X	X
General Systems Theory	X				X	X	X	X
IT Project Management	X				X	X		
History and Philosophy of Computer Science	X						X	X

AEB - Amistad Education Botswana
UP – University of Pretoria
UoW – University of Witwatersrand

SU – Stellenbosch University
STU – Stanford University
MIT – Massachusetts Institute of Technology
HU – Harvard University
CU – Cambridge University

REVIEW PERIOD

The qualification will be reviewed every 5 years. There focus of the periodic 5-year review is to among other things evaluate the employability of the students and the fit with the market needs.

Other information – please add any supplementary information to help the application for this qualification for NCQF Registration.

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