Aligning African Computing Disciplines' Graduate Attributes with International Standards

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ABSTRACT

This paper explores graduate attributes as is required of students in Computer Science and Information Systems disciplines in Africa in general and in South Africa in particular. Graduate attributes as envisioned by students and employers internationally are discussed to indicate the importance of graduate attributes from both of these groups' perspective. This discussion is followed by insights specific to computing disciplines in Sub-Saharan African countries. An overview of the graduate attributes required by the South African National Qualifications Framework and the South African Qualifications Authority is compared to the attributes suggested by the Association for Computing Machinery for computing syllabi. It is felt that this may help African and in particular South African computing departments to self-assess their programmes in terms of international standards.

Keywords: Graduate Attributes, National Qualifications Framework (NQF), South African Qualifications Authority (SAQA), Computing, Computer Science, Information Systems, Information Communication Technology (ICT).

1. INTRODUCTION

What skills must a graduate have to be able to function in the fast changing computing environment of the 21st century? What knowledge-base will give the graduate the edge to excel in a working career? These are the questions currently being asked by many, also in the computing world, who are re-evaluating what attributes constitute a graduate in 2012. In 1997 the South African Department of Education in a white paper defined the following graduate attributes as a goal with regard to the transformation of higher education: "… graduates with the skills and competencies that build the foundations for lifelong learning, including, critical, analytical, problem-solving and communication skills, as well as the ability to deal with change and diversity, in particular, the tolerance of different views and ideas …" [13]. The word "graduateness," although relatively unfamiliar, epitomises the complex concept of graduate attributes into a single term.

Graduateness is the achievement of learning outcomes and attributes that equip students to be innovative and effective in the workplace and active and informed citizens when they have completed their qualifications. Graduateness is furthermore the unique outcome of broader societal socioeconomic and geopolitical alliances [3], the vision, mission, product qualification mix (PQM), pedagogies, institutional reputation, discipline-specific reputation in the context of a specific higher education institution, the reputation of individual lecturers and their own reputation, the characteristics, commitment and endeavours of individual students and, lastly, the relevance of the qualification in the context of employability and research. This means that graduateness is the result of a range of interrelated, interdependent and mutually constitutive variables at a specific time in a specific socioeconomic and geopolitical context [4].

This paper surveys graduate attributes as is required of students in Computer Science (CS) and Information Systems (IS) disciplines in Africa in general and in South Africa in particular. First, graduateness as envisioned by employers is discussed to indicate the importance of graduateness for both employers and students in the global context. Next, an overview of the graduate attributes required by the South African National Qualifications Framework (NQF) and the South African Qualifications Authority (SAQA) is provided. The Association of Computing Machinery (ACM)'s curricula for CS and IS are then mapped to the Higher Education Qualifications Framework (HEQF) and SAQA principles. This mapping may help African computing departments to self-assess their programmes in terms of international standards and can be a preparatory phase towards international accreditation if desired. The paper concludes with insights on the socioeconomic context of Sub-Saharan African countries that can inform graduateness in this context.

2. GRADUATENESS AND EMPLOYABILITY: AN INTERNATIONAL PERSPECTIVE

Graduateness is concerned with a set of qualities that marks a person who has undertaken a degree course, whereas employability has an immediate practical concern relating to the way in which graduates can be assimilated into employment. In their study of university students in the United Kingdom, Glover et al. [6] found that for students "…*economic motivation is more important than the pursuit of knowledge…*" and that students do not see graduateness by itself as a sufficient basis for continued personal investment in university education. As a result, there is an increasing expectation amongst students and prospective students that higher education be directed towards improving their employability and thus their future employment prospects. This finding suggests that there is tension between graduateness and employability but it is debatable whether this tension is valid and legitimate.

In their employer satisfaction research, Harvey and Knight [7] found that employers were looking for transformative potential in graduates and they highlighted the following important graduate attributes: knowledge; a willingness to learn; the ability to work in a modern organisation; interpersonal skills and communication. In an industry panel discussion at the Midwest Association for Information Systems (MWAIS) in 2011 in Omaha, Nebraska, all three panellists[1] confirmed the continued validity of the attributes that they most seek in CS/IS employees, namely, foundational skills and an understanding of the fundamental concepts of the discipline (rather than just the latest technology) in order to be able to engage in meaningful problem-solving and designing innovative solutions [9]. At a subsequent keynote at the same conference the Managing Director of Information Technology (IT) at *TD Ameritrade*, Bob Beck, indicated that apart from core technical skills there are several other skills that are vital for continued career success in his company: the ability to work in and with teams; to deal with cultural diversity; to communicate effectively; to engage in cognitive thinking and to learn adaptively [9]. According to Beck, CS/IS programmes should:

- *Teach the basics, that is, reading, writing and arithmetic*
- *Coach collaboration through more emphasis on group projects*
- *Focus on 'business first, technology second' because of the importance of functional expertise*
- *Emphasise written and verbal communication, especially interpersonal interaction*
- *Inculcate understanding of global cultures, including social and political aspects*
- *Establish lifelong learning by instilling the desire to continue improving* [9]

In order to reach and concretise these general aims of computing programmes, colleges and universities may use the ACM curricula for the computing disciplines. These curricula have a long history of more than forty years and have been used widely to evaluate syllabi for the purposes of quality assurance and accreditation. Various curricula exist, including Computer Science, Information Systems, Information Technology, Computer Engineering and Software Engineering. These curricula are available at http://www.acm.org/education/curricula-recommendations. The Computer Science and Information Systems curricula will be used below to align the content of tertiary outcome guidelines in South Africa with international standards. This comparison may be used to plan computing programmes and to evaluate existing programmes against these benchmarks.

Whilst students in CS/IS may understandably be more concerned with their future employability than a well-rounded education and attaining graduateness, employability and graduateness is becoming much more closely integrated globally, although employability does not necessarily include a commitment to ethical practices or in showing responsibility to the environment and others [6]. Although students may not yet clearly understand that by pursuing graduateness they could contribute to satisfying their economic motivation for pursuing higher education, that is, employability, evidence suggests an increased desire by employers for graduate attributes in addition to core knowledge and disciplinary skills. It may well be that the recruitment practices and job descriptions of employers do not adequately communicate these expectations to their future employees and thus students and prospective students are not sufficiently aware of this altered state of affairs. The next section discusses graduateness within the context of South African higher education.

3. GRADUATENESS IN THE SOUTH AFRICAN CONTEXT

Whilst governments have a broader responsibility to ensure accountable citizens, they are also tasked with ensuring that they are able to supply the skills necessary for their national economies to be competitive in the global economy. All higher education institutions in South Africa, whether at traditional residential or distance learning institutions, are obliged to produce graduates that meet the requirements of the HEQF and SAQA regarding the exit level and critical cross-field level outcomes. Therefore all graduates from South African universities are expected to have the characteristics contained in the 'draft level descriptors' extracted from the Higher Education Act No. 101 of 1997 [14], represented verbatim in the first column of Table 1. Add to this the NQF critical cross-field outcomes [10], such as :

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[1] Panellists were Gerrit Schutté, Senior Vice President and CIO of *ConAgra Foods*; Anthony DeCanti, Vice President and CIO of *Werner Enterprises*; and Jake Chambers, a progam manager at *Google*.

- *Identifying and solving problems in which responses display that responsible decisions using critical and creative thinking have been made*
- *Working effectively with others as a member of a team, group, organisation, community*
- *Organising and managing oneself and one's activities responsibly and effectively*
- *Collecting, analysing, organising and critically evaluating information*
- *Communicating effectively using visual, mathematical and/or language skills in the modes of oral and/or written persuasion*
- *Using science and technology effectively and critically, showing responsibility towards the environment and health of others*
- *Demonstrating an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation*
- *Reflecting on and exploring a variety of strategies to learn more effectively*
- *Participating as responsible citizens in the life of local, national and global communities*
- *Being culturally and aesthetically sensitive across a range of social contexts*
- *Exploring education and career opportunities*
- *Developing entrepreneurial opportunities*

The combined characteristics of these two sets provide a very comprehensive profile of the ideal graduates in the South African context. The HEQF's set of characteristics deals with the quality and scope of graduates' knowledge, the problems they should be able to solve, how they should gather and interact with information, how they should be able to communicate and how independent they should be in their learning. The critical cross-field outcomes deals with the so-called "softer'" issues focusing on creativity, group work, self-efficacy, showing responsibility towards the environment and the health of others, systems thinking, reflectivity, and citizenship.

In the next section the internationally required outcomes of computing degrees (as defined by the ACM curricula for CS and IS [2;15]) are mapped onto the South African defined graduate attributes.

4. MAPPING HEQF/SAQA GRADUATE ATTRIBUTES ON THE REQUIRED OUTCOMES OF ACM CURRICULA

In Table 1 the outcomes of the IS and CS graduate programmes as required by the ACM curricula are mapped onto the HEQF and SAQA graduateness guidelines in order to reveal similarities and disparities. Some of the phrases in Table 1 are direct quotations from the referenced documents, while others are paraphrased or summarised.

Table 1. Mapping HEQF/SAQA Graduateness Characteristics on NQF Critical Cross-Field Outcomes and the ACM IS and CS Curricula's Graduate Attributes

HEQF/SAQA exit level outcomes on NQF level 7 (bachelor's degree)	**NQF critical cross field outcomes**	**IS2010 [15] (Outcome expectations for IS graduates, pp. 15-23)**	**ACM Computer Science curriculum 2008**
1a. A well-rounded and systematic knowledge base in one or more disciplines/fields	Using science and technology effectively and critically	Foundational and IS specific knowledge and skills; understand limitations of technology and related resources	High-level understanding of systems as a whole; knowledge and understanding of essential facts and concepts
1b. And a detailed knowledge of some specialist areas		Understanding fundamental organizational processes; domain fundamentals: business, government, health care, legal profession, etc.	Attention to rigorous thinking; knowledge and understanding of modelling and design
2. A coherent and critical understanding of one or more discipline/field's key terms, rules, concepts, principles and theories	Using critical thinking for responsible problem solving	Becoming experts in high level design and management of IT capabilities	Critical evaluation and testing
3a. Ability to map new knowledge onto a given body of theory	Demonstrating an understanding of the world as a set of related systems	Analysing legal and ethical implications of complex situations	Appreciation of the interplay between theory and practice
3b. An acceptance of the multiplicity of 'right' answers		Identifying and evaluating solution and sourcing alternatives	Significant project experience, showing the ability to integrate and apply principles and skills

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HEQF/SAQA exit level outcomes on NQF level 7 (bachelor's degree)	NQF critical cross field outcomes	IS2010 [15] (Outcome expectations for IS graduates, pp. 15-23)	ACM Computer Science curriculum 2008
4a. Ability to deal with unfamiliar concrete problems and issues using evidence-based solutions	Identifying and solving problems; participating as responsible citizens in the life of local, national and global communities	Designing revised processes	
4b. Ability to deal with unfamiliar abstract problems and issues using theory-driven arguments		Appling principles of process analysis to specific situations	Adaptability: possess a solid foundation to maintain skills as field evolves at fast pace
5a. Well-developed information retrieval skills	Collecting... information	Researching and applying industry reference models; integration of data	Information retrieval and management skills
5b. Critical analysis and synthesis of quantitative and/or qualitative data	Analysing, organising and critically evaluating information	Analysing existing processes; analysing information needs of organisation; mathematical foundations	Numeracy
5c. Presentation skills following prescribed formats,	Displaying critical and creative responses to problems	Observing, report writing, collaboration tools, presentations	
5d. Using IT skills appropriately	Developing entrepreneurial opportunities	Understanding how to use data to improve processes; seeing new opportunities to create value faster	International competitiveness
6a. Ability to present and communicate information and their own-ideas and opinions in well-structured arguments	Using and displaying creative thinking for responsible problem solving	Negotiating solutions that satisfy the political requirements for new processes	Communication and presentation skills
6b. Showing an awareness of audience	Showing responsibility towards the environment and health of others; being culturally and aesthetically sensitive across a range of social contexts	Customising processes to address cultural and ethnic needs	Being guided by social and cultural issues
6c. And using the academic/professional discourse appropriately	Communicating effectively using visual, mathematical and/or language skills in the modes of oral and/or written presentation	Negotiating with other role players about funding, service levels, quality, etc.	
7a. A capacity to operate in variable and unfamiliar learning contexts	Recognising that problem-solving contexts do not exist in isolation	Leading implementation of new processes; identifying solutions to secure data	Recognition that common themes and principles have broad applications
7b. Requiring responsibility	Problem-solving that displays responsible decisions	Understanding, managing and controlling IT risks	Professional responsibility
7c. And initiative		Assuming inspiring leadership at various levels	
8. A capacity to accurately self-evaluate and identify and address own learning needs	Organising and managing oneself and one's activities responsibly and effectively; reflecting on and exploring a variety of strategies to learn more effectively; exploring education and career opportunities		Self-management of learning, development, time and organisational skills

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9. An ability to effectively interact in a learning group	Working effectively with others as a member of a team, group, organisation, community	Leadership, collaboration and team work	Teamwork

It is clear from the comparison in Table 1 that there is high correspondence between the ideal graduate attributes suggested by SAQA and the ACM, both in IS and CS. The CS curriculum places less emphasis on negotiation and leadership skills and involvement in academic discourses, while the IS curriculum places less emphasis on rigorous thinking. However, these are limited to slight differences in emphasis. It is, actually, rather surprising that both disciplines share most of the "softer" graduate attributes, assuming and underlining the idea that these contribute to a graduate student's employability since CS is often perceived as a "harder" science than IS. The implication of the high correspondence is that South African computing departments may model their curricula on the ACM's guidelines and be sure that they also meet SAQA's requirements. The derived mapping could form a roadmap for quality assurance by CS/IS departments.

Some gaps, however, have also been identified and these need to be addressed by syllabi committees at individual institutions. In the ACM Computer Science 2008 curriculum no specific mention is made of the solving of divergent concrete problems. Report writing and presentations are also underplayed, as well as negotiation and leadership skills. On the IS side, rigorous thinking and methodology could receive more attention. The capacity of self-evaluation and of identifying one's own learning needs is not stated clearly in the IS curriculum, but it may be implicit – if the graduate would move to a new application domain, the knowledge and skills related to domain fundamentals should be acquired.

This study is limited to IS and CS curricula, and follow-up work should also look at other curricula, such as software engineering, computer engineering and ICT.

Since graduateness is situated in a particular socio-economic and geo-political context the next section considers the graduateness of computing teaching/curricula situated in the broader context of Sub-Saharan Africa.

5. GRADUATENESS AS THE RESULT OF COMPUTING TEACHING/CURRICULA IN SUB-SAHARAN AFRICA

How should the career skills and learning outcomes be integrated and interpreted in terms of the graduateness of computing students? And how should computing curricula underpin these attributes? These were the questions that were asked at a two-day summit held in Kampala, Uganda, in August 2010 [5].

The summit was attended by forty computing scholars from all parts of Sub Saharan Africa (SSA): West Africa, South Africa and East Africa. In this study South Africa is included as a SSA country; however, in many definitions of SSA, South Africa is excluded because it is felt that the Western European influences are much stronger in South Africa than in the rest of the region. "SSA begins immediately south of the Sahara Desert below the Tropic of Cancer (latitude 23½° N) through the Equator down to 35° South, just north of South Africa. North Africa is not included in this region, as it resembles the Middle East much more than the rest of Africa" [8].

The aim of the Ugandan summit was to determine what graduate attributes are required of SSA graduates and whether there are requirements that are particular to SSA – that is over and above those defined by the ACM (Association for Computing Machinery) [1]. For example, graduates from SSA should be entrepreneurs (much more than their counterparts in the developed world) and should be able to build their own information technology (IT) businesses, since small and medium enterprises (SMEs) have proven to contribute significantly to the economic growth in the SSA region [11]. Apart from the computing academics who were invited to the summit, three local Ugandan (IT) industrialists were also asked to contribute on what skills the Ugandan industry requires of SSA graduates and what they felt were currently lacking.

The local business identified problem-solving skills (to tackle practical problems), being able to work independently and the ability to communicate as areas of concern. The problem areas identified by the industrialists fed into discussions on the second day of the summit. The delegates then identified seven *perspectives* (building blocks of skills or knowledge areas) they felt should be part of each SSA curriculum, namely: Science and Technology (S&T); Soft and Research skills (S&R); Society and Development (S&D); Environment (ENV); Business and Entrepreneurship (B&E); Institutional Skills (INST); and Practical Skills (PR). The delegates drew up a grid of the current status of their regions' curricula (in terms of these perspectives) and what they deemed the ideal situation would be [12].

Six academics, two each from East-, West- and South Africa, undertook to collect data about the syllabi of the computing programmes currently being taught in their respective regions. Syllabi from a total of 22 computing programmes were collected and were analysed both quantitatively and qualitatively to validate the gaps between the existing curricula and the identified perspectives. Most of the syllabi analysed were from CS programmes, the rest were from Information Technology (IT), Computer Engineering (CE), Information Systems (IS) and Software Engineering (SE) programmes.

It is not surprising that the most popular of the computing programmes in SSA is still CS (the oldest discipline among the computing disciplines) (with the exception of South Africa where IS is taught at various tertiary institutions). The weighting allocated to each of these perspectives for the different programmes were then calculated. It was determined that for a CS programme to be relevant in SSA, for example, half of the programme should constitute S&T modules with approximately a tenth of the weight of the programme being dedicated to practical components. Furthermore, approximately a fifth of the weight of the programme should be dedicated to S&R and the rest to S&D, ENV, INST and B&E respectively. An IS programme could have even more business and other soft skills and less S&T elements. Follow-up research could explore the ideal balance. The aims of the African computing community seems to support the international drive towards delivering a balanced graduate with particular emphasis on the so-called "soft"-skills that are often neglected.

6. CONCLUSIONS

Whereas graduateness is about the unique qualities of a person who has completed a certain curriculum, employability is about improving their employment prospects as a result of outcomes achieved. This paper confirms that employers are looking for graduates with the ability to work in a modern organisation, with an emphasis on group projects and lifelong learning. Furthermore, integrative and applied learning needs to be demonstrated through the application of knowledge, skills and responsibilities to solve complex problems. These are skills and attributes that graduateness seeks to promote.

Graduates of all universities in South Africa are intended to attain graduateness by reaching exit level outcomes and delivering critical cross-field level outcomes. There is a close correspondence between the outcomes of the ACM CS and IS curricula and the HEQF/SAQA exit level outcomes and the critical cross-field outcomes on NQF level 7. Some gaps were identified that need to be filled by higher education institutions. Furthermore, graduateness is the unique outcome of the strategy followed, the programmes as a result of the strategy followed and the risk management practices of the higher education institutions. Each program and, more specifically, each curriculum has a unique weighting of attributes, based on context that gives its students a unique blend of capacity. In a Computer Science program in Sub-Saharan African countries, it was suggested by Rai et al. (2012), for example, that 50% of the program should be geared towards Science and Technology, 20% to Soft and Research skills, and the rest (30%) to Society and Development, Environment, Business and Entrepreneurship, Institutional and Practical Skills. Information Systems programmes may even have a higher percentage of soft skills.

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