On the Conception of Computing Curricula in an African University

Sunday O Ojo (PhD)
Department of Computer Science, University of Botswana
Private Bag UB 00704, Gaborone, Botswana
Email: ojoso@mopipi.ub.bw

ABSTRACT

This paper presents the conception of computing curricula in an African university with a further attempt at balancing computability and usability concerns in computing curricula. The key changes to the existing curricula in moving from a Subject system to a Semeterised Course system is presented. The alignment of the approach to computing curricula conception with the local needs is discussed. Key issues emanating from the case is examined from the operational, contextual and strategic perspectives.

Keywords: Computing Curricula, Computability Concern(CC), Usability Concern(UC)

1. INTRODUCTION

In its report [ACM/IEEE-CS, 2001] the IEEE/ACM Taskforce on Computing Curricula 2001 rightly observed that in the early conception of computing curricula it is common that the term 'Computing' is used to encompass the labels 'Computer Science' [and] 'Computer Science and Engineering' but specifically excludes programs in other computing disciplines such as information systems[ACM/IEEE-CS, 2001]. This conception of computing as a discipline fails to address critical issues of computing in practice [Wilson, Greenleaf & Trenary, 1989]. Hence, the various quests to create other computing disciplines, notably, Information Systems and Software Engineering[Denning et al, 1989]. More recent notable proposals on IS include ACM/AIS/AITP, 1997; Lidtke D et al, 1999; ACM/AIS,2000; IS-2000; and those on Software Engineering include IEEE-CS,1999.

The discipline of computing continues to grow. A major change in the discipline over the past decade is the enormous broadening of the scope of the field [ACM/IEEE-CS, 2001]. Denning(1999) has enumerated two dozen professional specialities that fall into the domain of computing. [ACM/IEEE-CS, 2001] observed that while it is possible to debate this classification scheme, undoubtedly, the expansion of the field has a significant impact on the broad domain of computing as a discipline. In advocating for a broader view of the computing discipline, the report posits that the disciplines of Computer Science(CS), Computer Engineering (CE), Software Engineering (SE) and Information Systems(IS) taken together, represent much of academia's coverage of the discipline of computing. However in practice, this split in the discipline of computing encourages the emerging disciplines to diverge while defining their own territories. A consequence of this is that important aspects of computing will be omitted from study in academic curricula [Wilson, Greenleaf & Trenary, 1989].

Earlier [Ojo, 1997], in relation to the traditional conception of computer science curricula, had characterised the underlying problem encouraging this divergence as the tendency of computer scientists to over-emphasise computability concern at the expense of usability concern. According to [Ojo, 1997], *Computability concern(CC) deals with formulating mathematical and scientific theories of computing and providing formalised tools and techniques [Ojo,1997]. The objective of this is to ensure technical impeccability of the products of computing activities. That is, technical efficiency, portability, completeness, and other technical performance issues of computing systems. CC also focuses on the theoretical soundness of the underlying ideas, at the expense of usability of the ideas. Establishing computing as a scientific discipline is made an end in itself, rather than a means to an end. Usability concern (UC), on the other hand, deals with giving adequate recognition to what we shall call the 'contextual milieu' of computer applications and evolving appropriate mechanisms to handle them. By contextual milieu we mean the human and organisational related issues of computing in practice.*

The traditional perception of the computing discipline is that motivated by CC and so most Computer Science and Engineering curricula are CC-dominant. A CC-dorminant conception of computing views it as purely a mathematico-scientific discipline. This view engenders the doctrinaire belief in the purity of science of computing, devoid of the social facts of reality. This conception of computing discipline often leads to a mismatch between theory and practice, which in turn results in a mismatch between the graduates of computing programs and market demands [Ojo, 1997]. It constitutes a limiting factor in human capacity development for effective computing technology deployment. Consequently, achieving the socio-economic development objectives of its adoption is adversely affected.

In addressing this problem, [Ojo, 1997] proposed an integrative approach to computing curricula development that balances computability and usability concerns of computing, through integration of IS ideas into a CS curriculum. Interaction with the various stake holders in the public and private sectors of the Botswana economy, has shown the need for the adoption of a more radical approach to university computing curricula which is holistic, collaborative, cross-disciplinary, innovative, integrative, forward-looking and multi-perspective. This is to minimise the gap between market demands and the graduates of the computing education programs.

This paper is a follow up on the work reported in [Ojo, 1997]. It reports on further works done in the quest to evolve market-driven computing curricula at the University of Botswana (UB). Appropriate balancing the CC and UC in computing curricula is seen as the core issue. The limitations of the earlier approach reported in [Ojo, 1997] are identified. Current approach being implemented is presented. The operational, contextual and strategic perspectives to issues in the curricula development and implementation are discussed. The thinking underlying the approach advocated in this paper is that conception of university computing curricula should be holistic, collaborative, cross-disciplinary, innovative, integrative, forward-looking and multi-perspective. This thinking is hinged on the belief that both CC and UC are part of the same process, and therefore should not be viewed as competing alternative processes of thought. Rather, they are successive and complimentary episodes of thought involved in the evolutionary process of computing as a discipline. Following the view in [Ogunniyi, 1986], computing as a discipline should be seen as a truly dynamic human enterprise rather than a dogma.

2. THE LOCAL HUMAN RESOURCES NEEDS

The University of Botswana (UB) is at present the only university in Botswana. As such, the country depends mostly on the university to meet its computing human resources needs. Interaction with the various stakeholders both in the public and private sectors of the economy has revealed two broad categories of local computing curricula needs expected to be met by the university. These are, (a) Computing Curricula aimed at producing computing graduates;, and (b) Computing curricula aimed at producing graduates of other disciplines adequately equipped with computer-using skills for their future work life.

Computing Curricula Needs for Computing Graduates

According to the report of a recent study by ICL, there is a shortage of computing professionals in Botswana [Kansichi, 2001]. This has culminated in the country depending mostly on expatriate computing personnel. The report further reveals that, 90% of computing project managers, enterprise systems implementers, and business analysts/consultants are expatriates, technical designers are 99% expatriate, while systems integrators are 60% expatriate. Gaborone (2001) describes these imported computing personnel as being artificially overprized. Given the global acute shortage of computing skills, Botswana cannot continue to depend on expatriate computing personnel. A deliberate program that will increase the critical mass of locally-produced well-equipped computing personnel thus becomes an imperative.

The Botswana Government is the largest employer of computing professionals in the country. Over the years, the Government through its Government Computer Bureau has been discussing with the Department of Computer Science at the University, the need for a proper blending of computing theory and practice in the program offerings. The Advisory Board for the Department does concur with this need. The Directorate of Public Services Management, charged with the responsibility of recruiting public services personnel, recently underscored this need in its proposal to government. In it, there should be two parallel cadre of computing personnel within the government Ministries and departments, namely, the Technical computing cadre and the Information Systems cadre. It is hoped that these will to respectively meet the technical-oriented and the business-oriented computing human resources needs in the public sector [Ridderof, 1999].

In a correspondence to the Department of Computer Science from the management of the Government Computer Bureau [Ramaribana, 2001] there has been an increased demand for a balanced technical cum business-oriented approach to the development of computing personnel. The need for computerized systems to support business processes in government has also increased during the first few years of the current National Development Plan period (1997 to 2003). It was further reported that Government has responded by decentralizing the funding of Information Technology(IT) projects and creating IT Units in ministries and departments in order to enable them greater autonomy in the deployment of computerized systems to support their business. This greater deployment efforts is currently being hampered by an acute shortage of adequately skilled IT staff. In addressing this problem, the government has been sending students and public officers abroad for degree in IS. It is clear that the country will need to train many more computing professionals who are well-equipped with technical and business-oriented skills, if the civil service is to remain efficient in comparison to similar services throughout the world. In addition to industry-oriented computing personnel, there is also a shortage of computing academics. For example, since its inception, the department has not succeeded in recruiting citizens even at the lecturer level of appointment; except through the University's Staff Development Fellowship program. Similar shortage is being experienced by other tertiary institutions offering computer studies programs. Hence, a need for a deliberate internal effort to embark on the production of more citizens with potential for academic computing career.

Given the above, there is a need for computing curricula that enables the production of computing graduates who are adequately equipped with necessary 'hard' and 'soft' knowledge and skills for organizational computing systems development and deployment, as well as intellectual capacity for further studies.

Computing Curricula Needs for Non-Computing Graduates: In the university, there is increasing dependence on the computer and information technologies for academic information sourcing and dissemination. All students in the university without an exception need to have computing skills to effectively utilize the technologies which are readily available in the university, towards their learning effectiveness. Based on Botswana's economy need for graduates in various disciplines with computing skills, the Botswana government has been sponsoring its workforce on computing skills acquisition programs. A number of departments from the University have assisted the government in this regard. Added to this, the Government's desire through its Vision 2016, to effectively utilize information technology for the nations social and economic development. There is therefore a need to produce graduates of other discipline with appropriate level of computing knowledge and skills for use in their future work life.

3. APPROACH TO COMPUTING CURRICULA CONCEPTION

Given the computing human resources needs expressed in section 2, the UB approach to the conception of computing curricula should be holistic, collaborative, cross-disciplinary, innovative, integrative, forward-looking and multi-perspective. It is holistic when it takes account of the nature and categories of computing personnel needs as expressed in section 2.. That is, it should recognize the need for Computing curricula aimed at UB producing a) computing graduates with adequate potential for both academic and practitioner career and b) non-computing graduates of disciplinary areas of Education, Science, Business, Humanities, Engineering, etc., who are well equipped for the challenges of the information age. The approach is collaborative when it involves stakeholders contribution. It is cross-disciplinary if it recognises that Computing draws its foundations from a wide variety of discipline and so the curricula should draw inputs from relevant disciplinary areas to enable appropriate blending of necessary 'soft' and 'hard' elements. It is innovative if it recognises that the frontiers of knowledge are ever expanding and so represents a package that is well adapted to the target needs. It is forward-looking if it recognises that the frontier of computing is ever expanding and therefore provides a basis for accommodation future changes in the socio-cultural and technological environment. It is multi-perspective if it provides a basis for viewing issues of computing from different but complementary perspectives, such as social, technical and socio-technical perspectives..

Earlier Approach

Tables 1 and 2 below show the category of computing curricula provision in the university:

Table 1: Computing Programmes for Computing Students

Program	Target Audience
BSc(Computer Science)	Undergraduate computing degree students
Diploma(Computer Studies)	Undergraduate computing diploma students

Table 2 Computing Programmes for Non-Computing students

Program	**Target Audience**
Faculty-specific Computer Awareness programs	Non-computing undergraduate students

Table 3: Computing Programmes for Non-Computing students

Computer Awareness Progam	**Target Audience**
CA101 Computing Methods	Business students
ECA101 Computer Awareness	Education students
CS100 Introduction to Computing for Science Students	Science & Engineering students
CA100 & CA101 Introduction to Word processing & Spreadsheet	Social Science students
Hum101 Introduction to Computers	Humanities students

In Table 1 are the BSc (Computer Science) and Diploma (Computer Studies) offered by the Department of Computer Science aimed at producing computing degree graduates and sub-degree diploma holders, respectively. Table 2 shows that computing curricula provision was made for non-computing students through Faculty-specific courses in computer literacy which were offered by each Faculty to their respective 1st year students. These Faculties include Business, Education, Engineering & Technology, Humanities, Science, and Social Sciences. The Faculty of Science offered its Computer Awareness course to both the Science and Engineering students. The courses were taught by different Computer Awareness lecturers based in the Faculties. From Faculty to Faculty variations in content, focus, emphasis and delivery are observed. Also, except in the Faculties of Science and Engineering, the computer awareness programme was at best informal, ad hoc, and non-standardized and lacked focus in ensuring the preparation of the non-computing undergraduate students for the challenges of the computing and information age.

Table 4 Non-Traditional CS Courses Integrated into CS Curricula

CS371 Information Systems & Organisations
DCS260 Business Computer Applications
CS291 Communication Skills for Computer Scientists
CS374 Management
CS471 Social Issues of Information Technology
CS473 Economics of Information Technology
CS 346 Systems Analysis and Design

Table 5: Some of the CS Courses with IS Topics incorporated

CS Course Modules	**Nature of IS Topics Incorporated**
CS 481 Database System	Incorporating socio-organisation and managerial issues; Information resources management, Use of Business-driven Information Engineering Methodology; Taught from socio-technical perspective
CS444: Software Engineering	Incorporating Professional and ethical responsibility issues, Software Safety and social vulnerability; Project management; Systems resources management.
CS471 Object-Oriented Software Development	Incorporating O-O Systems analysis and design
CS394 Human-Computer Interaction	Incorporating Human factors and Ergonomics of Man-machine interaction.

Earlier Approach to Balancing UC-CC in Computing Curricula for Computing Students, as reported in [Ojo, 1997], was the integration of IS ideas into the computer science curricula. Options considered and implemented in the integration process included: a) integrating IS ideas as course modules into the syllabi; and b) incorporating IS topics into existing CS course modules. Table 4 shows some of the non-traditional CS courses included in the CS curricula through this approach. Incorporation of IS topics into some existing CS course modules involved topics aimed at equipping students with 'soft' knowledge and skills, to complement the traditional 'hard' knowledge and skills in such course modules. Table 5 shows some of the courses and the nature of IS topics incorporated with the teaching of the courses from a socio-technical perspective.

There is also students industrial attachment during long vacation, which is optional.
Feedback from the various stake holders both in the computing academia and the industry, showed that this approach only partially addressed the issue of CC-UC balancing towards meeting the identified needs. It was considered to be a palliative measure that falls short of being adequately holistic, collaborative, cross-disciplinary, innovative, integrative, forward-looking and multi-perspective. Hence a need for a more effective approach to university computing curricula towards addressing the needs identified in section 2 above, more adequately

Current Approach
The current approach builds upon the earlier approach to address the local needs more adequately and appropriately. The current approach is more holistic, collaborative, cross-disciplinary, innovative, integrative, forward-looking and multi-perspective. During the year 2000, the University decided to change from Subject system to the Semesterized Course(or Modular) system. Academic programs in the university were expected to be revised in line with the new system. Taking advantage of the opportunity, computing curricula offerings in the university were restructured. This resulted in the review of the existing, and introduction of new, undergraduate curricula offerings. It also involved the phasing out of the sub-degree diploma program and the initiation of the introduction of postgraduate program. In addition, a university-wide Computer & Information Skills program emerged, to replace the faculty-specific computer awareness programs. The summary of the key changes in the structure of the university computing curricula is given in Table 6. For the purpose of ease of reference the changes are labeled P1 through P6, respectively.

Table 6: Earlier and Current Computing Programs

	Earlier Program	**Current Program**
P1	Faculty-specific Computer Awareness Programmes	University-wide Computer & Information Skills Programme
P2	Sub-degree Diploma(Computer Studies) program	Program is being phased out
P3	BSc(Computer Science) program	Revised BSc(Computer Science) program
P4		3-stream Bachelors of Information Systems (BIS) program
P5		BSc/BIS Combined Major/Minor, Minor/Major, and Multidisciplinary degree programs

P1 – The University-wide Computer & Information Skills program [UB-GEC-2,2001] is a cross-faculty General Education program being offered by the Computer & Information Skills Unit(CISU) under the Department of Computer Science. This program replaces the defunct faculty-specific computer awareness program. The Unit is staffed with one Coordinator, a group of Computer Awareness Lecturers (one for each Faculty), and a team of subject Librarians from the university Library and Information Services Department. The program has two components to it, that is, a) the Computer Skills component and b) the Information Skills component. The team from the Library & Information Services Department handles the Information Skills component, while the Faculty Computer Awareness Lecturers take charge of the Computer Skills component. In its conception, this program is designed for all non-computing students in the university. It takes cognizance of the universal and particular aspects of computer and information skills requirements. It also recognizes the need for students to be able to use computers flexibly, creatively and purposefully such that they can identify what they need to accomplish, determine whether a computer will help them to do so, and then be able to use the computer as part of the process of accomplishing their task. Further, computer skills and information skills requirements of students are integrated.

Table 7: The Computer & Information Skills Course Modules
GEC 121 Computing and Information Skills Fundamentals I
GEC 122 Computing and Information Skills Fundamentals II
GEC 221 Information Management Skills
GEC 222 Problem-Solving with Spreadsheet
GEC 223 Web Application Skills
GEC 322 Multimedia Information Presentation Skills

Table 7 shows the structure of the new program. GEC121 and 122 are compulsory for all 1st year students throughout the University. The remaining course modules are optional.

In Balancing CC-UC in Computing Curricula for Non-Computing Students, two distinct but complimentary skills embodied in the program are recognized. These are, the computing skills and the information skills. The program recognized the need to integrate Information Literacy Skills with the Computing Literacy Skills. The integration is in such a way that the combined skills can be used in practical problem-solving using the computing and information technologies. In this regard three requirements for an effective integration of the two skills are recognized in the program design. These are, a) the skills are made directly related to the target application domains through contextualised laboratory exercises to reflect the varying particular needs of students in the different Faculties b) the skills themselves are tied together in a logical and systematic information process model; c) practical hands-on problem-solving experience with the technologies is critical to acquiring the skills in the learning process and d) the information skills component is infused throughout the teaching of each course module.

P2: The Diploma (Computer Studies) program is being phased out after ten years of its existence. The main reason for the decision to phase it out was the dwindling employment fortune of the graduates. The employment fortunes of the graduates have been varied from year to year. In the early years, the employment fortunes were very high but within the past 5 years, there has been fluctuations. Two key factors were identified as contributing to this situation. Firstly, there are changes in the computing industry environment with regards to the trend towards more preference for higher calibre of computing professionals than those at the diploma level. This may not be unconnected with the increasing sophistication of computing technology and applications and the consequent computing skills demands.. Secondly; the increase in the number of institutions in the country which are offering similar programs. This has led to a saturation of the economy with computing personnel of this cadre, beyond what the economy has capacity to absorb [Ojo, 2001].

P3: The revised BSc (Computer Science) & The Bachelors of Information System (BIS) Single Major program [UB-CS,2001; UB-BIS,2001]: Table 8 shows the integrative structure of the revised BSc (Computer Science) program and the new BIS (Computer Information Systems) program. Key distinguishing elements of the revised BSc(CS) program include: a) the existing CS and IS course modules were revised with further CC-UC balancing in mind, b) new CS and IS courses are introduced, at each level c) all IS courses which are not indicated as core courses for the BSc (Computer Science) program, are indicated as optional courses at each level. and d) four areas of concentration (i.e. Software Engineering, Information Systems, Knowledge-based Systems, and Scientific Computing) are introduced at the final year. This is to enable the students to be more focused with their future career interest in mind, in their selection of courses. The BIS program with three streams is a collaborative degree programme involving the Departments of Computer Science, Library and Information Studies, and Accounting & Finance. These departments are in the Faculties of Science, Humanities and Business, respectively. The BIS program has three streams: a) Computer Information Systems stream b) Information Management stream and c) Business Information Systems stream. These streams are offered in the three participating departments, respectively. The BIS is a program owned by the University while the participating departments own their respective streams. The program emerged through a political resolution of the initial turf battle between the three participating departments. Table 8 shows the integrative structure of the BIS(Computer Information Systems) and BSc(Computer Science) program.

P5: The Combined Major/Minor, Minor/Major and Multi-disciplinary degree program enables students to combine courses from the Computer Science(CS) or Computer Information Systems (CIS) streams with courses from one or more other programmes to obtain a combined degree. Combined degree (major/minor or minor/major) is a program of study composed of core and optional courses from two programs normally in the ratio of major: minor of approximately 70:30, as well as electives and general education courses. The combined (multidisciplinary) degree program is composed of core and optional courses from more than two subjects. For example, there may be a combination of three equally weighted subjects, or a series of individualized courses resulting into a program as may be approved by relevant authorities [UB-RAGR, 2000].

The bachelors degree programs, single or combined, are designed to take students who successfully completed the first year program from any of the UB Faculties. This is with the proviso that they must have taken the first year mathematics course modules offered in either the Faculty of Science or the alternative first year mathematics courses being offered in the Faculties of Social Science and Business. This entry-level flexibility has been introduced to attract students from non-pure science background. Students with such background has more potential to appreciate the need for CC-UC balancing, that their counterparts with pure science background.

4. ALIGNMENT OF APPROACH WITH THE NEEDS

The computing curricula needs in Botswana were presented in Section 2. The approach to the conception of the computing curricula at the UB aligns with these needs in the following respect. Firstly, the Computer & Information Skills program provides course modules ranging from basic to advanced level of computer and information literacy skills for non-computing

Table 8: BSc(CS) & BIS(CIS) Courses	CS	CIS
CSI231 Discrete Mathematics I	√	√
CSI241 Structured Programming	√	√
CSI292 Information Systems Fundamentals	√	√
CSI261 Machine Organization	√	√
MAT271 Introduction to Mathematical Statistics	√	√
CSI232 Discrete Mathematics II	√	√
MAT212 Introductory Linear Algebra	√	√
CSI252 Operating Systems Concepts	√	√
CSI242 Data Abstraction and Data Structures	√	√
CSI272 Computer Communications Network	√	√
CSI311 File Systems and Data Management	√	√
CSI322 Algorithm Analysis and Design	√	
CSI341 Introduction to Software Engineering	√	√
CSI315 Web Technology and Applications	√	√
CSI361 Computer Architecture	√	
CSI371 IS Resources Management	√	√
CSI331 Numerical Methods I	√	
CSI351 Assembly Language Programming	√	
CSI342 Systems Analysis and Design	√	√
CSI332 Programming Languages	√	
CSI382 Formal Languages & Automata	√	
CSI362 Database Concepts	√	√
CSI352 Industrial Attachment	√	√
CSI392 Human Computer Interaction	√	√
CSI312 Programming Language Translation	√	
CSI372 Expert Systems	√	√
CSI373 Economics of Information Technology	√	√
BIS302 Decision Support Systems I		√
CSI314 Decision Support Systems II	√	√
CSI393 Multimedia Computing	√	√
CSI403 Project I	√	√
GEC411 Business Communication	√	√
CSI461 Computer Communications Networks	√	√
CSI423 Systems Programming	√	
CSI421 Operating Systems	√	
CSI411 Complexity and Computability Theory	√	
CSI441 Software Engineering	√	√
CSI471 Object Oriented Systems Development	√	√
CSI481 Database Systems	√	√
CSI451 Knowledge Engineering	√	
CSI491 Pattern Recognition	√	
CSI493 Computer Graphics I	√	
CSI433 Algorithmic Graph Theory	√	
CSI414 Information Interfaces and Presentation	√	√
CSI405 Project II	√	√

Table 8: BSc(CS) & BIS(CIS) Courses	CS	CIS
CSI442 Artificial Intelligence	√	
CSI452 Computer Simulation	√	
CSI422 Operations Research	√	
CSI462 Distributed Systems	√	√
CSI472 Social Issues of Information Technology	√	√
CSI494 Computer Graphics II	√	
CSI412 Topics in Computing	√	√
CSI432 Intelligent Interfaces and Systems	√	
CSI434 Knowledge Management Systems	√	√
CSI482 Information Systems Engineering	√	√
CSI443 Numerical Methods II	√	
CSI431 Formal Methods	√	
CSI484 National Information Systems Infrastructure	√	√
Courses from the other 2 BIS streams		√

Graduates. Secondly, the revised BSc(Computer Science) program supports the integration of pure(CS) and applied computing (IS) courses in one program. It also provides for areas of concentration in the final year. This would enable a student to be focused in course selection. The regulation for course selection is made such that a student has the opportunity to be balanced in course selection with respect to pure and applied computing courses. Thirdly, the BIS program with three streams each housed in the Science, Business and Humanities Faculties, enables the production of computing graduates with diverse disciplinary background. This is in tune with the diversity of computing needs in Botswana. Fourthly, the combined degree program would enable the production of graduates with adequate combination of computing and other knowledge. This provides a basis for meeting the contextual diversity of computing application needs in the economy. Fifthly, there is flexibility in the admission requirements for the degree programs. This flexibility would enable students who complete 1st year in any of the Faculties - Business, Humanities, Social Sciences, Education and Science - to enter any of the programs, as long as they have requisite 1st year mathematics background. In general, computing curricula model adopted, with its provision for entrants to the programs from diverse background, as well at its accommodation of courses in both pure and applied computing, provides a solid basis for the production of appropriate graduates well suited for the context.

5. MATTERS ARISING IN PERSPECTIVES

The various issues that emerged over the years in the evolutionary development of the UB computing curricula can be considered in three perspectives. These are the Operational, Contextual and Strategic perspectives.

Operational Issues deal with curricula development and implementation issues which are resource-related. Such issues include physical infrastructure, funding and human resources. According to Tatnall (1997) for growth of curricula to occur there has to be an educational infrastructure – physical resources, central support facilities, teaching laboratories and human resources. He further reports that a study of the curriculum history of business computing reveals a complex interrelationship between computer technology, educational needs, institutional facilities, and the on-going development of curricula It is therefore very important that necessary resources for the implementation and sustenance of the curricula be in place. The university is at present 100% government-funded. The level of funding of the curricula implementation depends on the level of government funding provision to the University. There is shortage of senior faculty members. Computing laboratories and technical support services are not quite adequate, most especially for the Computer & Information Skills program. It is very crucial to bear in mind the operational feasibility of any curriculum model, at the development stage.

Contextual Issues
These are issues associated with the particularity of the local context with a bearing on curricula model adoption and implementation. These issues include the following:

Curricula Model Matching: According to the educationist, Wilson(1981), education does not take place in a cultural vacuum; every teaching and learning has a geographical, historical and socio-economic context. Most computing curricula models are developed mostly in the North Americas. They would always come with the warning note that they are designed primarily for that context. Commonly, African computing curricula developers depend almost entirely on such curricula models developed elsewhere, as the first point of call and a source of inspiration. Undoubtedly, borrowing from such curricula models from other contexts can accrue significant benefits. However, in doing so, the dangers of over-comparison may often far outweigh the benefits. Given this, to avoid curricula model mismatch, the UB computing curricula recognised computing curricula innovation as an imperative. The paradox of universality and particularity of computing is well recognized. In respect of the universal aspects of computing, a lot is drawn from the North Americans' computing curricula models such as IS '97, IS'2000, and Computing Curricula 2001. To take adequate care of the particularities, the context of the UB computing curricula, local needs analysis provided the basis for the objectives formulation and contents determination. Lessons from other curricula models and experiences should be based on the understanding that no single society or economy is the same as any other. After the general similarities between curricula models have been drawn, ample room should be left for purely well contextualised 'home grown' curricular extrapolations and simulations that adequately reflect the particularities and hence, realities of the local socio-economic environment. This is the thinking in the UB curricula model. Further, the adoption of a curricula model should not be viewed as a static process. Curricular model adoption should be responsive and adaptive to the changing circumstances in the local environment. For example the changes in the conception of the UB computing curricula shown in Table 6 is a response to the changing needs in the local environment.

Local Stakeholders Profile: A vibrant, well-developed and forward-looking computing industry has a key role to play in contributing to the evolution of appropriate curricular model in a country. However, the computing industry in Botswana is still at its developmental stage. There is still a very low level of awareness of the need for industry-academia partnership towards evolving appropriate computing curricula. Most organisations involved in computing are either just users or distributors who are simply locked in into their short-term profitability objective. This profile seems to have a limiting factor on their contribution to the university efforts towards ensuring the relevance of the computing curricula to the skill needs of the local environment.

Limits of Rationality in Computing Curricula Development: Experience in UB computing curricula development efforts revealed that, the path of a curriculum development process could be strewn with socio-political considerations, rather than pure rationality. Most individuals and/or departments that have anything to do with computing, often lay claim to some form of expert knowledge of the discipline of computing. Computing curricula could become fashioned to suit a particular individual or group interests; some others would seek to influence the curriculum content to ensure their indispensability in the implementation; course modules may reflect what an individual wants to teach, rather than what should be taught, and so on. Our experience in the emergence of the 3-streamed Bachelors of Information Systems is worth noting. It is a compromise between political decisions and interest-balancing. It is to ensure that none of the three departments/faculties loses out. Notwithstanding, the fact that such a program that cuts across traditional departmental/Faculty boundaries is seen as 'feat' in cross-disciplinary collaboration.

Strategic Issues

These issues deal with what strategy options for computing curricula model and implementation given the various realities of the local context. Some of these issues are now discussed:

Curricula Design Philosophy: There are two dimensions to the underlying curricula design philosophy. These are, curricula contextualisation and rationalisation. In contextualising the curricula, the programs are designed to provide students with a well rounded grounding in technical computing knowledge and skills. In addition, the programs stress the need for wider knowledge in order to understand computing in the context of its use. To this end the design of the programs are driven by graduates' need for contextual knowledge and skills in the following: a) Organisations, organisational processes and functions within organisations; b) the common concepts, strategies and tools required of any computer professional to effectively play his role as an agent of change, and c) Human relations and interpersonal skills for communicating effectively with other actors in computing application development.

In rationalizing the curricula, courses that traditionally belong to other disciplines (e.g. Mathematics, Management, Accounting, Library and Information studies, Marketing, etc.) are left to be offered to students in these departments. It is expected that students, through combined degree and elective courses selection will take such courses on board. Also, the course offerings in the programs include bridge-head topics that provide the necessary link between those courses taught in other departments and their applications in the discipline of computing. Also, for the same reason, for some courses (e.g discrete Mathematics), inter-departmental joint teaching approach is being adopted. Observance of the law of comparative advantage that engenders effectiveness and resources optimization in curricula implementation, lies at the core of this dimension to curricula design philosophy.

Appropriate Blending of 'Hard' and 'Soft' Sciences in Computing Curricula: Appropriate balancing of CC and UC computing curricula requires appropriate blending of 'hard' and 'soft' sciences.[Ojo, 1997]. Following the Science education philosopher, Kuhn(1975) as quoted in Ogunniyi(1986), we should not be interested in just science of computing but also, the socio-psychological context of applications of science of computing. Holding a doctrinaire belief in the purity of "hard" science of computing to the extent that it should not be 'adulterated' with the 'soft' science of the socio-cultural and organisational context of applications of computing, would not help in evolving computing curricula, appropriate for a context. Science and technology generally is value-laden. Science and technology of computing cannot be an exception. So it is of utmost importance that this reality be reflected in computing curricula development and implementation. This is where "soft science" courses such as Social, Ethical and Professional Issues of Computing come in handy in computing curricula. The UB computing curricula reflect this reality and so adopts the philosophy of computing-as-knowledge and computing-as-practice combined as two sides of the same coin.

Maximising the Synergy between Computing Teaching, Research and Professional Services: There is synergy between teaching, research and professional services. Activities in these three aspects of academic career are interactive with one impacting the other. For instance, as research ideas become developed and accepted they would have impact on courses which provide basic training[Wilson, Greenleaf & Trenary, 1989]. Devising appropriate integrative strategy that facilitates maximisation of this synergy is critical to evolving computing curricula that are appropriate and relevant. So it is also for healthy career development. In our kind of setting, time sharing among these three aspects is disproportionate, with teaching taking the lion's share always at the expense of the other two. This makes the task of evolving such a strategy to be all the more an imperative. Deliberate efforts is being made to evolve such a strategy. However, not much is being achieved as at present. This remains a challenge.

Evolving Appropriate Strategy for Stakeholders Involvement: According to the educationist Wilson(1981), where more employers are involved with those in the education system in defining the broad purposes of an education and training programme, a clearer goal is established. In addition to the usual informal unsolicited feedback from the employers of our computing graduates, there is a formal system of having an Advisory Board for each program, earlier referred to. This board played a significant role in contributing to the evolution of the UB computing curricula. One problem faced in constituting the board is getting industry representative with appropriate level of in-depth and broad-based intellectual capacity in the computing discipline. It has been hard getting people with at least a degree in computing as a member. A good number of the members seem to have a rather narrow knowledge that limits their contribution at meetings. The appreciation of the need for a holistic view of university education that transcends the narrow confine of the computing technology is often missing in some members' contributions. While every care was taken to avoid undue dictation from outside academia about what is(not) to be taught in an academic program, the vital role that these non-academic stakeholders could play in making computing curricula relevant to the local context, cannot be ignored. It is a key issue emanating from the experience in the UB case, that there is a need for evolving a more comprehensive strategy for involving the non-academic stakeholders in computing curricula development. Their involvement could provide an arbitrating forum for the combatants in the turf wars on balancing CC with UC in computing curricula.

The need to forge appropriate formal academia-industry link could facilitate stakeholders involvement. However, given the present developmental stage of the computing industry in the country it has been an up-hill task, convincing the people in the industry that they are partners with those in academia in ensuring that appropriate computing graduates are produced. Also, it is rare to have a research project funded by the industry. No formalised mechanism has yet been established for obtaining information feedback on the industry assessment of graduates of the programs. Generally, evolving a mutually beneficial link with the industry remains a key issue which has to be resolved. Efforts are on-going in this direction.

6. CONCLUSIONS

In this paper we have presented a case of the conception of computing curricula in an African university. Further attempt at balancing computability and usability concerns in computing curricula is presented. The key changes to the existing curricula in moving from a Subject system to a Semesterised Course system is presented. A framework for examining the key issues emanating from the case, from the operational, contextual and strategic perspectives, is seen. Given the various operational, contextual and strategic issues emanating from the case, and the way these issues were addressed in the present UB computing curricula, there is a cause for optimism about CS and IS growing together in African universities.

The socio-economic context of the computing applications in Africa raises problems of a new sort that require considerable restructuring of the traditional conception of computing as a pure science. It requires not just simply applying ready-made mathematico-scientific paradigms to new situations; rather finding new paradigms, or new ways of interpreting the old paradigms in order to appropriately address the challenges presented in the deployment of the science and technology of computing in Africa. As demonstrated in the case presented, there is a need for an approach to university computing curricula that is holistic, collaborative, cross-disciplinary, innovative, integrative, forward-looking and multi-perspective.

This definitely requires an appropriate integration of 'hard science' and 'soft science' paradigms into a single whole, to evolve a more flexible and comprehensive paradigmatic framework that gives equal treatment to computability and usability concern in the development of any computing education program. Evolving such a framework does pose an enormous challenge in the light of the issues that emanated from the case considered in this paper. It is hoped that this paper provides some direction in this respect.

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