Introduction of General Education Courses to Engineering Programmes at the University of Botswana*

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Complementary studies are fundamental for accreditation of engineering programmes in line with the Washington Accord. This paper presents the experiences of the University of Botswana in introducing General Education Courses (GECs) for the purpose of broadening the educational experience of all students, with particular reference to engineering students. Students registration data captured in the Integrated Tertiary Software (ITS) were analysed using Excel software. The five-year study period was from 2002 to 2007. Results indicate that engineering students mainly took GECs offered by the science and technology disciplines. It is concluded that GECs should be retained within the engineering programmes but the student advisory system should be improved and skills (e.g. IT competencies) that are important for professional development should be embedded in core courses instead of in general education.

Keywords: complementary studies; general education; engineering curriculum; accreditation

INTRODUCTION

THE IDEA that every university graduate should have some general knowledge outside his or her area of specialization is fully understandable and rational. The expectation that a graduate should be articulate, open minded and aware of sustainability constraints and obligations cannot be achieved without inclusion of general education (GE) in curricula. This requirement also applies to engineering graduates and hence GE is now a vital element of engineering education in a number of systems and countries [1].

Engineering and engineers can no longer be satisfied with technical knowledge. Increasingly often they have to answer questions involving social, ethical, ecological, economic and aesthetic considerations. In such situations engineers need to demonstrate a broad knowledge on issues and be able to assess the impact of engineering solutions in a global and societal context. Engineering curricula must not only teach engineering theory, experimentation and practice but should be *relevant, attractive* and *connected* [2].

In engineering, core courses deal with technical aspect and subject specific topics whereas courses from other disciplines such as business, law, and the humanities are categorized as complementary studies, electives or general education. GECs develop knowledge and proficiency in 'soft' skills in contrast to 'hard' engineering skills, which are taught through compulsory coursework [3]. GECs could be found, in one form or the other, in all engineering curricula in continental Europe [4], the UK [5], North America [1, 6] as well as in new engineering educational systems [7].

Although there is extensive information on review and diversification of engineering programmes [3–5, 8] there are hardly any studies on the practical aspect of the introduction of courses related to general knowledge in such programmes.

GE AS A REQUIREMENT FOR ACCREDITATION OF ENGINEERING PROGRAMMES

Accreditation is currently a desired benchmark for any engineering programme. Accredited programmes attract students and encourage them to consider a particular programme of study over a gamut of other competing curricula. Accreditation assures that a programme has met quality standards set by a professional body and successful completion of an accredited degree is a prerequisite to the most direct pathway to becoming a professional engineer. Engineering programmes in different countries are designed to satisfy the accreditation requirements imposed by national professional bodies to allow graduates to achieve professional engineer status. The recognition and equivalency of the engineering programmes in different countries is determined according to the Washington Accord [9]. The Accord provides a mechanism for mutual recognition, across borders, of engineering qualifications accredited in each member country by the other accord signatories in their home countries. Each of the countries involved has expressed confidence in the quality

assurance mechanisms and processes of the other

countries. The mutual recognition of accredited engineering degree programmes generally leads to exemption from the educational requirement for practising in each of the signatory countries. The Washington Accord covers only professional engineering undergraduate degrees and its signatories are engineering organizations in Australia, Canada, Hong Kong, Ireland, Japan, New Zealand, Singapore, South Africa, the UK and the USA. Recently India, Germany, South Korea, Malaysia, Singapore, Taiwan, Russia and Sri Lanka have been admitted as Provisional members of the Accord. A Provisional member is given two years to review its academic programmes, curricula and syllabuses, examination and evaluation system to the standard of the Accord.

The Washington Accord includes elements of GE or complementary studies in the attributes and professional competency profiles for graduate engineers [9]. The attributes show that engineering programmes must not only teach the fundamentals of engineering theory, experimentation, and practice, but should prepare students for a broad range of careers and life-long learning. Since an increasing number of engineering graduates may never practise engineering directly it is crucial that 'general skills' are embedded in their education. Some authors recommend that engineering education should become more flexible to support diverse career aspirations and engineering courses should address a broad range of concerns as related to: environmental, political and social issues; international and historical contexts; and legal and ethical ramifications [10, 11].

Therefore the requirements, in terms of GECs, for all accredited degrees are that they should produce robust graduates who are articulate, aware of the financial, moral, legal, economic, environmental and cultural constraints and obligations under which they practice, are aware of current management practices and committed to and prepared for lifelong learning. Apart from the technical and engineering content, GE is also indirectly embedded in the curricula in the form of:

- health and safety, resource issues and sustainability;
- inter-personal skills (including the supervision of staff and the ability to work as a member of an engineering team) and
- management and business topics.

In some situations, GE may not be listed as a formal condition for accreditation but it is indeed required in all engineering programmes [6, 12, 13]. Some accrediting bodies do not quantify the component of GE to be included in a proposed programme [14–16]. However, some authors recommend that the size of the core area of engineering subjects 'plus a minimal content of complementary studies considered acceptable for accreditation strictly determine the basis for any other consideration for international equivalence of academic qualification' [17].

ACADEMIC PROGRAMMES AT THE UNIVERSITY OF BOTSWANA

The University of Botswana (UB) is currently the only tertiary institution in Botswana offering degree programmes in Engineering. The University was established in 1982 and had no engineering faculty until the erstwhile Botswana Polytechnic was incorporated as the Faculty of Engineering and Technology (FET) into UB in 1996.

Prior to 2002 UB followed a subject based system of mainly year-long courses (although there were some semester-long courses) and progression from year to year was dependent on passing the end-of-year examinations held once a year. The system was clear to all stakeholders, especially the sponsors, as it was obvious what level the student was studying and when (s)he was to graduate. However, the system was not friendly as it lacked flexibility in almost all the aspects of academic regulations including assessment, progression, passing and failing, repeating, prerequisites and co-requisites.

In 2002 UB undertook a major reorganization of its academic programmes by changing from a subject based system to a semester system with course credits and grade point averages. Prior to semesterisation, UB recognised the importance of pan-university courses for the purpose of imparting new skills and competencies to graduates, for example 'Computer Skills', 'Communication Skills', but there was no holistic approach to manage these areas. Hence, there was a discourse on how such common courses, with transferable skills, could be offered more effectively and whether such courses should be part of a much broader concept of GE modules. It was envisaged that conversion to the new system would stimulate a university wide curriculum review that would achieve the following objectives:

- improve student-determined choice of courses;
- introduce more flexibility;
- facilitate the design of new programme offerings;
- manage student workload in a more effective manner;
- facilitate clear entry and exit points into programmes;
- be responsive to employers' expectations of UB graduates and
- promote the overall quality of programmes.

INTRODUCTION OF GENERAL EDUCATION COURSES AT UB

Semesterised programmes consist of four categories of courses, namely core, optional, elective and GE. General Education courses were introduced to broaden the students' perspective in order to: 'promote critical thinking, intellectual growth, a broader perspective in analysis of issues, and

Table 1. General education course groupings at UB [18]

Area	Description	Objective
1	Communication and Study Skills	To promote acquisition of better communication of ideas and study habits.
2	Computer and Information Skills	To promote the utilization of computers and Information Technology in University studies and to provide vital life-long skills.
3	Modes of Inquiry and Critical Thinking	To gain an awareness of various methods of inquiry and promote how to think critically in the academics and life in general.
4	Physical Education, Health and Wellness	To encourage students to develop a physically active way of living and adopt positive attitudes to health so as to enrich the quality of life.
5	Sciences and Technology	To promote understanding of the contribution of science and technology in life.
6	World Civilisation	To promote an understanding of the diversity and complexity of different world cultures.
7	World Economy and Business Skills	To instil an appreciation of how economic and business activities shape human affairs, nationally, regionally and internationally.

general skills for life-long learning' [18]. They 'count towards the overall credit requirement for the award, but are not part of the subjects for the award'. All students at UB were required to take GECs. However, in order to avoid compromising the integrity of each academic programme at least two thirds of the total credits required for graduation should consist of core and optional courses. The remaining one third of the credits is from GE and elective courses. Elective courses were defined as courses that count towards the requirements of an award but are not core or optional courses required for a particular programme.

The GECs were to address such cross-cutting issues as employers' expectations, competence in communication skills, ICT and information skills literacy, gender, HIV/AIDS, environment, energy, cultural diversity and globalization. GECs were not specific or specialized courses but general enough to be grasped by non-specialists in a particular discipline. Some of the obvious examples were GECs in business for engineering students to broaden their understanding of the business and financial environment, and some courses in the humanities to appreciate cultural diversity and philosophy.

The GECs were grouped into seven areas as shown in Table 1. Each of the areas was to have a set of courses at different levels, and students from any Faculty could enrol in such courses. In addition to courses in Area 3, all other courses were also to include elements of critical inquiry and analytical skills.

GEC was introduced without any restrictions on students' registration but the students were allowed to take elective courses only from their subject areas. Therefore, it was possible for a student to take a GEC from his/her department. However students were allowed to select GECs in consultation with their personal tutors and with the approval of the offering department.

Each GEC was assigned two credits which are equivalent to two lecture hours per week for a 15-week semester. In the majority of cases it means that the course is delivered in a 2-hour lecture per week. However there are more contact hours for courses with tutorials/practicals such as those in Area 2, i.e. Computer and Information Skills.

The minimum number of credits to be passed from GE was 16 but with the following specific conditions [18]:

- at least four credits in courses in Areas 1 and 2 in each of the first two semesters of study;
- at least two credits from Area 3, and
- the balance from at least two other areas.

ENGINEERING PROGRAMMES AT UB

The Faculty of Engineering and Technology at UB is relatively small compared with other faculties of the university. There are four engineering programmes leading to a BEng degree in Construction Engineering & Management, Civil Engineering, Electrical/Electronic Engineering and Mechanical Engineering. The programmes commence with the first year (post O level) within the Faculty of Science. It is followed by a transfer of engineering students to FET, where they follow a Common Engineering Year 2 curriculum. After one year fundamental courses in engineering, the students then specialize in different disciplines in Years 3, 4 and 5. Between Years 2 and 3, and again between Years 4 and 5, they undergo Industrial Training (IT). The first period of IT is 4 weeks to enable students develop hands-on experience, whereas the second period of IT is of 20-week duration. The numbers of student registered for engineering programmes in the academic year 2008–2009 are as shown in Table 2 and Fig. 1 shows the composition of courses for engineering programmes.

Table 2. BEng students by programme 2008–2009

Civil Engineering	238
Construction Engineering & Management	126
Electrical and Electronic Engineering	243
Mechanical Engineering	192
Total B.Eng. students (spread over eight semesters)	799*

*Does not include the first two semesters when students are in the Faculty of Science

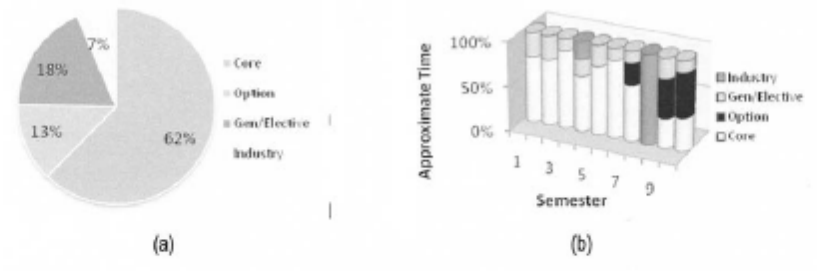

Fig. 1. Types of courses in engineering programmes: (a) total; (b) by semester.

There are also non-engineering students in FET taking programmes in Design and Technology Education, Industrial Design, Mining, Architecture, and Urban and Regional Planning.

METHODOLOGY OF STUDY

Students' registration was captured on the Integrated Tertiary Software (ITS) system which is a commercial software with proprietary capabilities. The ITS provides fully integrated enterprise resource planning administrative software systems to support various functions and processes of the university such as financial and student systems. Although the systems within the ITS suite are fully integrated with one another, it is possible to use individual systems in a flexible and modular way [19].

The integrated suite of Student Management systems handles student records including qualification, subject and course registration, class information and examination records. The Student Web enabler system allows registered students to access the ITS through the Internet.

Students in each department were registered in their cognate faculties. Students were allowed to deregister from a course within three weeks of the start of the semester. Students records were extracted from the ITS located in the UB intranet. Excel was used to analyse, manage and present data.

RESULTS AND DISCUSSION

General education courses offered at UB

Apart from the four compulsory GE courses in Areas 1 and 2 (Communication and Study Skills 1 & 2 and Computing & Information Skills Fundamentals 1 & 2 there were 48 other GECs with some registered students. The distribution of the GECs in different areas and levels of study is presented in Fig. 2. Table 3 shows details of some GECs referred to in this section.

As can be seen in Fig. 2(a), the majority of GECs were offered in Level 2—73%, almost all of the remaining (25%) were in Level 3; there was only one GEC in Level 4 and none (apart from the compulsory ones) in Level 1. Most GECs were offered in Area 5, Science & Technology (27%), followed by Area 7, World Economy & Business

Table 3. List of some of the GEC courses offered

Area	Code	Course name	Level	Faculty
1	GEC111	Communication & Study Skills I	1	CSSU*
	GEC112	Communication & Study Skills II	1	CSSU
	GEC211	Advanced Writing Skills	2	CSSU
	GEC213	Advanced Communication Skills	2	CSSU
	GEC312	Introduction to Rhetoric	3	Humanities
2	GEC121	Computing & Information Skills Fundamentals I	1	Science
	GEC122	Computing & Information Skills Fundamentals II	1	Science
	GEC222	Problem-Solving with Spreadsheet	2	Science
	GEC223	Web Application Skills	2	Science
3	GEC232	Critical Thinking—A Life Tool	2	Humanities
4	GEC248	Human Nutrition	2	Science
	GEC249	Human Sexuality	2	Science
	GEC441	Special Education	4	Education
5	GEC256	History of Technology	2	FET
	GEC257	Ancient & Modern Structures	2	FET
	GEC258	Art and Science of Design	2	FET
	GEC356	Renewable Energy	3	FET
7	GEC275	Basic Concepts in Marketing	2	FET

* Communications & Study Skills Unit

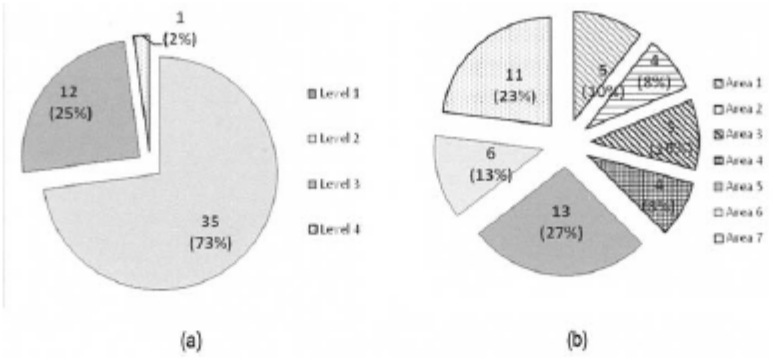

Fig. 2. Distribution of GECs offered at UB: (a) by level; (b) by area.

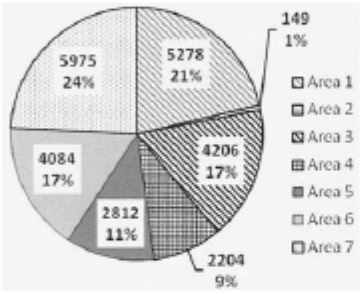

Fig. 3. Number of students per area of GE courses.

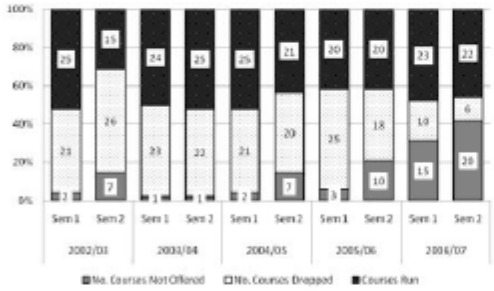

Fig. 4. History of the 48 originally approved GE courses.

(23%), the other areas had a comparable number of courses (8% to 13%).

The total number of students registered for GE courses in five years, from 2002/03 academic year to 2006/07, were 24 708. The most popular area was Area 7, which had 24% of all GEC registered students, followed by Area 1 with 21% and Areas 3 and 6 (both 17%). The least popular was Area 2; Computer & Information Skills with only 149 students (1%) registered within five years from two compulsory courses in Year 1 (Fig. 3).

Initially, students deregistered from a huge number of courses during the three-week 'add and drop' window following the commencement of a semester. However, the number of dropped courses stabilized reaching only six at the end of the period under consideration (Fig. 4). The number of GECs actually run in each semester was more or less the same throughout the period under consideration, although on average only half of the 48 originally approved courses were run in each semester. It was observed that no new GECs were introduced after 2002.

Figure 5 shows the most and the least popular GECs. The ten most popular GECs accounted for 58% of all GE registrations, whereas the ten least popular was only 1.8%, which indicates that the latter courses should probably not have been run.

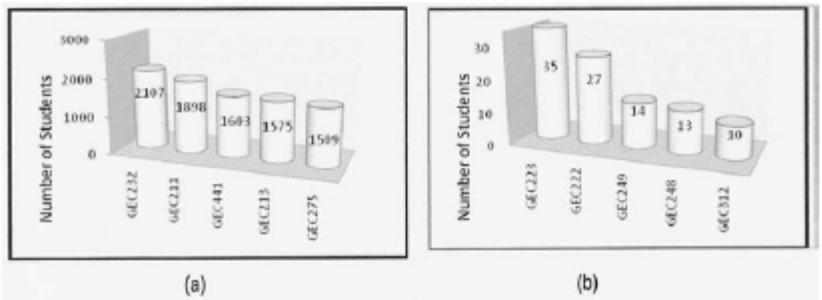

Fig. 5. GECs taken by UB students: (a) most popular; (b) least popular.

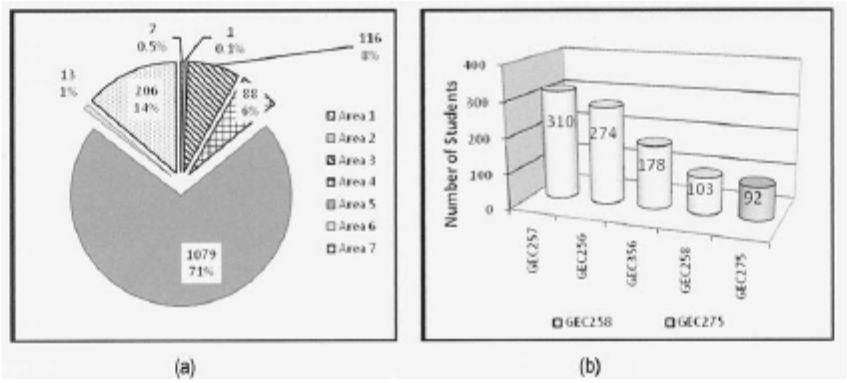

Fig. 6. GECs taken by engineering students: (a) by area; (b) by popularity.

General Education (GE) courses in engineering programmes at UB

Some elements of complimentary studies were present in the old UB academic programmes (subject based system). However, the importance of such courses was not emphasized. In the case of engineering programmes the GECs were limited only to Technical Communication (2 hours per week for 1 year) and Computer Studies (three semesters of 4 hours per week between Years 2 and 3). There were no other subjects that could be classified as GECs, although there were courses in Industrial and Business Organization (3 hours per week). These complementary courses constituted approximately 10% of total contact hours in the programme.

In the new engineering programmes introduced during semesterisation the students were to comply with regulations concerning GE courses. Therefore, engineering students took the four compulsory courses in Year 1 in Areas 1 and 2 (Communication and Study Skills 1 & 2 and Computing & Information Skills Fundamentals 1 & 2). Apart from that they made a personal selection of the other GECs offered in the university. During the five academic years covered in the study there were 799 engineering students who registered 1510 times for GE courses (excluding the compulsory GECs). The distribution in different areas is presented in Fig. 6(a). The distribution shows that 1079 GECs registration of engineering students (71%) was in Area 5, i.e. Science and Technology. The distribution of registrations within this area shows that the majority of students registered for courses offered in FET.

Four of the five most popular courses among engineering students were actually courses from FET (Fig. 6(b)) and the fifth one (GEC 275) from the Faculty of Business. The number of registration in these four courses was 865, i.e. 58% of total number of GECs registrations.

Both, Fig. 6(a) and 6(b) indicate that the number of engineering students registered for GECs outside of the Science & Technology area was small. The trend for engineering students to take GECs from their own Faculty increased throughout the study period. For example, the total number of registration for GECs offered by FET was 1259 out of which there were 888 engineering students and 353 non-engineering FET students (making a total of 1241) and only 18 students from other faculties (Fig. 7). The other major GECs engineering students offered were in World Economy & Business (206 registrations; 14%). The areas such as Communication & Study Skills (7 or 0.5%), Physical Education & Wellness (88 or 6%) and World Civilisation (13 or 1%) were almost completely ignored. Amazingly, they did not take GECs in Computer & Information Skills, where there was only one (1) registration of an engineering student.

The total number of engineering students who registered for any GEC was 640 out of 799 enrolments, which implies that not all students even did one GEC. As seen in Fig. 8, the majority of students registered for rwo GECs (219 or 34%), followed by one GEC (177 or 28%) and three GECs (127 or 20%). As the regulations required

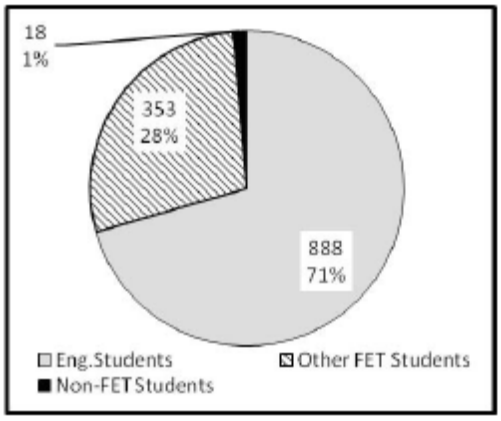

Fig. 7. Registrations for GECs offered by FET.

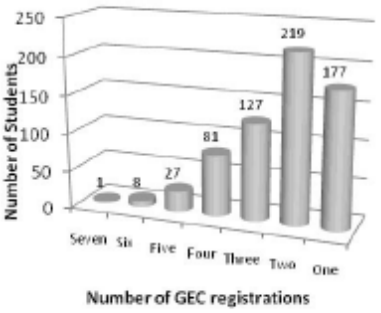

Fig. 8. Number of students for GEC registrations.

students to obtain at least 16 credits from GECs (equivalent to at least eight courses) all the students who registered for less than four did not fulfil the requirements (the other four were compulsory GECs at Level 100). The non-compliant students may be those following 'transitional regulations' (i.e. for students who were registered in the programmes before semesterisation was introduced), which were less restrictive on GE requirements.

DISCUSSION

Preliminary reports through interviews of stakeholders and teaching staff indicate that the semesterised programmes are preferred to the old subject-based system. The objectives of university wide programme review as presented above were achieved. Each of the principal stakeholders (students, sponsors and employers) expressed satisfaction in the semesterised programmes. Students and sponsors appreciate removal of regulations that barred students from progressing and retaking failed courses. The revised programmes offer a level of flexibility that was non-existent in the old subject-based system. For example, students can now register on part time basis if they are in employment or if not qualified to take the number of credits for full time students.

The focus of this paper is on GECs at UB with particular reference to engineering programmes. Table 4 presents a summary of the results and comparison of distribution of GECs registrations between different areas for all UB students and also for engineering students. The objective of the introduction of a pool of GECs at UB was to infuse some general knowledge to all graduates. GECs are available in all seven identified areas to promote robust graduates. However, implementation of the courses did not achieve the desired 'broad-based educational experience' because all learners have principally participated in GECs provided 'in-house', i.e. within their faculty or departments. So what lessons have been learnt from this exercise? The quota for each GEC registration was small because of limited classroom space. The university has embarked on constructing larger lecture theatres that may only be available in two years time. Until then it seems more pragmatic to discard the concept of specially designed GECs in favour of the existing electives in faculties. Electives (across all faculties and knowledge areas) should be availed by each department in the form of a list from which students can make their choices.

Another lesson learnt is that a well defined and effective advice system for students would enhance their selection of GECs. Before semesterisation, the University adopted a system of 'course tutors by year of study' to engage and advise cohorts of students. However that system was terminated with the introduction of semesterisation. With hindsight it seems that the erstwhile system should have been retained and improved upon such that a student and an advisor could sit down to select course offerings outside the core engineering curricula that would enhance a student's professional skills and competencies. One to one student–advisor services would allow for students' future career aspirations to be catered for in choosing the courses.

It is also evident that GE is not the proper way to introduce skills that are important for professional development. The number of registrations beyond Year 1 for courses in areas of Communication Skills and Competence in IT and Information Skills is deeply disappointing, especially for engineering students. In order to improve communication and computer skills for professional students, it is necessary to prescribe relevant courses as core in the curricula and also incorp-

Table 4. Summary of enrolment for GECs

Area*	No of all GEC registrations	[%]	No. of BEng students	[%]
Area 1: Communication and Study Skills (5)	5278	21	7	0.5
Area 2: Computer and Information Skills (4)	149	1	1	0.1
Area 3: Modes of Inquiry and Critical Thinking (5)	4206	17	116	7.7
Area 4: Physical Education and Wellness (4)	2204	9	88	5.8
Area 5: Science and Technology (13)	2812	11	1079	71.5
Area 6: World Civilisation (Humanities) (6)	4084	17	13	0.9
Area 7: World Economy and Business Skills (11)	5975	24	206	13.5
TOTAL	24708	100	1510	100

* The number in brackets is the total number of GECs offered in a particular area.

orate these skills into other core courses. For example, some engineering departments that offered computer core courses before the introduction of semesterisation dropped them altogether hoping that courses under GE mode would suffice. Unfortunately students did not take higher order GECs in computer science and the level and focus of compulsory GECs in the area were not satisfactory for engineering curricula.

Should GECs be retained in the engineering curriculum? The answer is a definite 'Yes' and modalities should be devised to introduce the elements of general knowledge effectively to engineering students. As discussed earlier, specially prepared GE courses may not be the best route.

CONCLUSIONS

Engineering programmes seeking accreditation by the Washington Accord members should include GECs or complimentary studies in their curricula. GECs were deliberately introduced into the engineering programmes at UB as part of a complete review of academic programmes at the university. The new system of semesterised courses was more effective and flexible than the old subject-based system. GECs were developed in seven areas and made available to all students irrespective of their programme of study. However the students mainly took GECs offered by their respective faculties and this scenario limited the advantages that would have been achieved by the new system.

In view of the foregoing, the students' advice system should be improved so that students and academic members of staff would agree on a student's personal choices of GECs. Also a wider pool of GECs should be offered in the form of Elective courses, which are already available in faculties.

Generally there is a dearth of information in the public domain on complementary studies in engineering programmes. Therefore a more rigorous measurement and assessment of GECs in engineering programmes at UB will be pursued and reported in future.

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