The design, implementation and evaluation of the Introduction to Engineering programme (Intro Engineering) for prospective engineering students at the Vaal University of Technology, South Africa

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ABSTRACT: The purpose of this paper is to present findings with regard to the design, implementation and evaluation of the Introduction to Engineering programme (Intro Engineering) at Vaal University of Technology, Vanderbijlpark, South Africa. During the design phase, emphasis has been placed on the problems experienced in South Africa with regard to the shortage of skilled labour within the fields of science and engineering. During the implementation phase, attention is focused on the methods used to enhance hands-on mathematical, science and communication skills in order to increase student throughputs in engineering. During the evaluation phase, the accent is on the impact of this programme on the number of enrolments within the Faculty of Engineering at Vaal University of Technology, as well as the degree of skill enhancements obtained by students. In the article, the authors suggest that the objectives of the Intro Engineering programme have been achieved with minimal changes to the pilot programme.

INTRODUCTION

With the rapid advances in technology, the demand for a skilled and educated workforce is on the increase. However, only a small proportion of school graduates obtain university exemption – and thus degrees – in South Africa. Furthermore, there is a high failure rate among first year students, in particular black students [1]. It follows, then, that only a small number of students obtain science-based degrees. As such, the long-term need for engineers and scientists is not adequately addressed in South Africa.

PROBLEM STATEMENT

Many countries, whether industrially developed or newly industrialised, recognise the crucial role of an effective system of education as part of their national plan for social and economic development [2]. Education prepares people, in a general way, for potential future roles and positions, which are not always clearly defined [3]. Education is involved with enhancing people's ability to think for themselves and it thus provides people with the opportunities needed for personal enrichment and employment via the acquisition of basic knowledge and skills.

A unique feature of the South African Higher Education Qualifications Framework, referred to in the New Academic Policy, is the Articulation Column [4]. This provides for horizontal and diagonal articulation. Diagonal articulation generally means that a learner may be required to undertake additional enrichment learning in a specific target area prior to being admitted to a target programme.

It has been proposed by the Council on Higher Education (CHE) that programmes that fall into the Articulation Column be made up of 60 credits (one semester of full-time study) in order to allow training providers to offer short, focused programmes that meet specific in-service or upgrading needs of adult learners.

In the higher education sector, both policy makers and academics have come to recognise the need for special academic development programmes to facilitate the success of promising but under-prepared students [5]. Despite the wide variety of, and many differences between, academic development initiatives, one common purpose runs through them all like a silver thread: the need to optimally develop each student's potential, that is to learn and study effectively, to cope with the demands of their studies and to attain a level of performance that matches their abilities and strength of commitment [6].

A need exists at the Technikon level for some form of upgrading/skills enhancement programme aimed at enriching those prospective students who do not initially make the admissions list [7].

INTRO ENGINEERING PROGRAMME

Programme Design and Development

Based on the above need, the Unit for Lifelong Learning at Vaal Triangle Technikon (later Vaal University of Technology), Vanderbijlpark, South Africa, was approached by the Electronics Department of the Faculty of Engineering during 2001, to design, develop and implement a modular-based introductory technology and skill enhancement programme for prospective engineering students. It was decided to name the programme *Intro Engineering*, as the aim of the programme is to uplift those students that are rejected from the mainstream engineering courses as a result of inadequate Grade 12 results.

Potential engineering student's Grade 12 results are rated, with an emphasis on mathematics, physical science and English, as requirements for admission to engineering. Not all applicants are successful and it is not ideal for prospective students who do not qualify for the mainstream admissions list to be referred to other tertiary institutions.

In order to identify the needs of those students who do not initially qualify for admission into a mainstream engineering course, the initiators of the Intro Engineering programme approached first year engineering lecturers, as well as Grade 12 teachers. The lecturers and teachers were then asked to identify problems within these subject areas.

Based on the discussions held, it was determined that the main emphasis of the Intro Engineering programme should focus on enhancing the mathematics, physical science and communication skills of prospective engineering students.

Programme Structure

Intro Engineering is structured to run over a ten-week period during the first and second semester of the academic year. The programme is further split into two modules. Module 1 is presented over a four-week period and Module 2 over a six-week period. The teaching time is allocated to each subject as follows:

- Communications: 9 hours per week
- Mathematics: 10.5 hours per week
- Physical science: 10.5 hours per week

Communications Skills, Module 1, deals with inter- and intra-personal life skill orientation. The aim of this module is to enhance the skills identified in research as negative contributing factors in the failure rate of first year students [8][9]. Communications skills, Module 2, deals with basic language aspects. The aim of this module is to enhance English language proficiency in engineering.

Mathematics, Module 1, deals with basic algebraic equations, solving problems and enhancing hands on mathematical skills. Module 2 deals with trigonometry and geometry linked to engineering mathematical skills required for first year engineering.

Physical Science, Module 1, deals with mechanical engineering aspects. Module 2 introduces students to the basics of chemistry and electrical engineering.

Teaching Methods Employed

In terms of the outcome-based approach to education, as accepted by the South African Qualification Authority, the teaching of languages falls under the learning area of language literacy and communication [10]. The skills of reading, listening and observing are emphasised. Research indicates that it is reading that promotes the essential cognitive development skills one must process in order to succeed in adult life [11].

Comprehension is the focal point of the reading process as it involves relating vocabulary to experience; understanding ideas, concepts and processes; recognising relationships; making comparisons; drawing inferences; reflecting, interpreting and reading between the lines. As these skills are mastered, comprehension occurs and leads to one being able to critically evaluate ideas, which is necessary within the field of engineering [12].

The second important specific outcome of the learning area – language literacy and communication – is that learners use language in order to learn [10]. This can be interpreted as the intrinsic value of language as an instrument for problem solving, decision making and creative thinking – critical and evaluative – that needs to be developed across the entire curriculum [13].

As success in the field of mathematics and science is related to the student's ability to relate vocabulary to experience; to understand ideas, concepts and processes; to recognise relationships; to draw comparisons and inferences; to reflect, interpret and to read between the lines, it was thus decided to employ an integrated approach to teaching, between the three subjects that comprise the Intro Engineering programme.

Emphasis has also been placed on the acquisition of skills. As such, a hands-on approach is embedded in the mathematics and science curricula.

Programme Implementation

The first Intro Engineering programme was presented during the first semester of 2002. It is important to note that the pass mark required in Module 1 for each subject is 60%. Therefore, the student must pass all three subjects with a mark of 60% or higher in order to register for Module 2. Continuous assessment is utilised in Module 1 in the form of tests, practical, assignments, presentations and so forth in order to ascertain the Module mark.

In Module 2, students require a course mark of 50% (based on the same continuous assessment methods) in order to qualify for the examination, which is at the end of Module 2. The pass mark required per subject is 60%, which is made up of 50% coursework mark and 50% examination mark. The student must, therefore, pass all three subjects in Module 2 with an overall mark of 60% or higher in order to qualify for registration for a mainstream engineering programme.

Enrolment Composition

Table 1 lists the composition of the first enrolment group for Module 1, while Table 2 describes the composition of the first enrolment group for Module 2.

Table 1: Composition of the first enrolment groups for 1st Semester 2002 (Module 1).

	No of Students	% of students
Enrolments	113	-
Cancellations	1	-
Gender		
Male	65	58%
Female	47	42%
Age Groups		
16-18 years	44	39%
19-21 years	51	46%
22-24 years	15	13%
> 24 years	2	2%

Table 2: Composition of the first enrolment groups for 1st Semester 2002 (Module 2).

	No. of Students	% of students
Enrolments	75	-
Cancellations	0	-
Gender		
Male	48	64%
Female	27	36%
Age Groups		
16-18 years	34	46%
19-21 years	36	48%
22-24 years	4	5%
> 24 years	1	1%

It can be seen from Table 1 that 58% of the enrolled students for Module 1 were male and 42 % were female. The students ranged in age from 16 to 32 years.

As can be seen from Table 2, 64% of the enrolled students for Module 2 were male and 36% were female. The students ranged in age from 16 to 32 years.

Programme Evaluation

Table 3 lists the overall results of the first enrolment group for Module 1, while Table 4 describes the overall results of the first enrolment group for Module 2.

Table 3: Module 1 results (1st Semester 2002).

Total students enrolled		112
Cancellations		1
Mathematics		
Number of students passed		100
Pass %		89%
Average % obtained		72%
Science		
Number of students passed		78
Pass %		71%
Average % obtained		67%
Communications		
Number of students passed		79
Pass %		71%
Average % obtained		62%
Gender		
Number of females passed	28	60%
Number of males passed	49	75%
Overall Results		
Number of students passed	77	69%

As can be seen in Table 3, the pass rate for Module 1 was 69% (77/112). The overall pass rate for Mathematics, Module 1 was 89%. The overall pass rate for Science, Module 1 was 70%. The overall pass rate for Communications, Module 1 was 71%.

75% of the male students who enrolled for Module 1 qualified for Module 2. 60% of the female students who enrolled for Module 1 qualified for Module 2. In total, 77 students (69%) passed all three subjects in Module 1.

As can be seen in Table 4, the pass rate for Module 2 is 25% (19/75). The overall pass rate for Mathematics, Module 2 is 35%. The overall pass rate for Science, Module 2 is 31%. The overall pass rate for Communications, Module 2 is 47%.

Table 4: Module 2 results (1st Semester 2002).

Total students enrolled		75
Cancellations		0
Mathematics		
Number of students passed		26
Pass %		35%
Average % obtained		71%
Science		
Number of students passed		23
Pass %		31%
Average % obtained		68%
Communications		
Number of students passed		35
Pass %		47%
Average % obtained		68%
Gender		
Number of females passed	3	11%
Number of males passed	16	33%
Overall Results		
Number of students passed	19	25%

It can be seen that the percentage of female students (11%) who passed both Modules 1 and 2 is significantly lower than the number of male students (33%) who passed both modules.

Table 5 summarises the throughput rate for the first enrolment group for Intro Engineering.

Table 5: Throughputs for 1st Semester 2002.

Modules 1 & 2 Throughput	%
Mathematics	23
Science	21
Communications	31
Females passed	6
Males passed	25
Overall pass	17

Table 5 indicates the overall throughput rates for the first Intro Engineering programme. The overall throughput rate for the Intro Engineering programme was 17%. This implies that 19 students were thus able to enrol for a mainstream engineering programme.

The overall throughput rate for mathematics was 23%, for science 21% and communications 31%. In all, 6% of female enrolments successfully completed both modules and 25% of the male students.

CONCLUSIONS

The overall throughput rate for the Intro Engineering programme is 17%, which is slightly lower than the Technikon throughput rate of 20-25% for the same subjects in the first year of engineering.

The overall throughput rate for the Intro Engineering programme indicates that 19 students, who would not normally have been accepted into the field of engineering, could now enrol for their first year in engineering at the Vaal Triangle

Technikon. This implies that the Intro Engineering programme was successful with regard to the increase of enrolments in the field of engineering.

The percentage of female students who passed both Modules 1 and 2 is significantly lower than the number of male students who passed both modules.

RECOMMENDATIONS

The academic progress of the 19 students who passed the Intro Engineering programme are being tracked throughout their study career at the Technikon in order to ascertain if the overall throughput rate in the field of engineering increases. Data obtained from each successive Intro Engineering programme should be analysed in terms of students' pass rates and throughputs in order to determine the long-term success of the programme.

Continuous evaluation of module content, as well as lecturer capability, should take place so as to ensure that the quality and content of the teaching material is maintained throughout the duration of the programme. An investigation into a possible correlation between English proficiency and pass rates in mathematics and science should also be conducted.

The significant difference between the pass rates for male and female students should be investigated to determine the cause thereof.

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