Foundation Mathematics for Diversity: Whose Responsibility and What Content?

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This paper looks at the increasing number of students who want to enter fields of study at university needing a mathematical background, who do not satisfy the normal admission criteria or simply lack the necessary skills and competencies. The questions that are raised are: (i) Does a university have any responsibility to assist these students to obtain the mathematical qualifications, skills and competencies they lack? (ii) How can universities identify which students will really benefit from special admissions programmes? (iii) If a university does take on this responsibility, what content is appropriate for a foundation mathematics course?

Introduction

The political transformation in South Africa since 1994 has posed major new challenges for South African universities. In the previous era, historically white universities had the luxury of well-prepared students, most of them from the same high quality educational system. The opening of access to the university to students of all racial groups in South Africa meant that students now come from diverse educational backgrounds. The problems associated with this are clearly reported in the National Commission on Higher Education which aimed at setting guidelines for higher education in South Africa. This report calls for the provision of degree and diploma programmes with extended curricula in key subject areas, and argues for increased integration of academic development activities within tertiary education ([1], 136-137, 144-145). Many documents stress that increased access should not be matched by a corresponding increase in dropout rates. For example, the Education White Paper 3, [2], reads

> The higher education system is required to respond comprehensively to the articulation gap between learners' school attainment and the intellectual demands of higher education programmes. It will be necessary to accelerate the provision of bridging and access programmes within further education. It is of utmost importance that the political transformation of a university does not just result in the admission of unprepared students to the university without giving them a reasonable change to succeed. The university must also go through an academic transformation to address the problems associated with changing student demographics.

One major problem is that a large number of students from previously disadvantaged communities want to enter into studies which need a mathematical background, but they do not satisfy the normal admission criteria or simply lack the necessary skills and competencies. There is a lack of qualified mathematics teachers in some communities, and as a result, many pupils with the ability and potential to do well in mathematics are denied the opportunity, which in turn restricts their career possibilities. Statistics indicate that only 27.3% of African pupils in their final school year in 1993 enrolled in mathematics and only 25.5% of these passed the subject,

i.e. 7% of all African matriculants. (See [3], 16-19.) Much effort has been made to improve this situation over the last few years, but the problem is still immense.

The responsibility for mathematics upgrade programmes and courses

If the question "Must universities become involved with upgrading or foundation or bridging courses for school leavers?" was asked of academics at the University of Port Elizabeth in the 1980's or even early 1990's, the majority would have responded with a very emphatic **no**. A typical response would have been "It is surely the responsibility of the schools to supply the university with well-prepared students, and pupils who cannot pass their final schools exams with high enough marks simply should not be admitted to the University". Drastic changes in the student demographics at the university over the past 5 years have convinced many academics that there is a need for such programmes, and this attitude is no longer in line with the university's mission. The university's future depends on student numbers and the ability to produce graduates from all racial groups, and the importance of upgrading is now acknowledged. Reality dictates that universities must get involved in upgrading programmes, rather than rely on an improvement in the schools situation, or support from enrichment centres and community colleges.

Since the early 1980's, higher education institutions have typically adopted two approaches to student under-preparedness, namely an "academic support" approach and a "bridging" or "foundation" approach. The work of Agar, Hofmeyer and Moulder [4] provides a useful overview of both approaches (cf Hunter [5]). Academic support uses a number of interventions, such as subject specific and general skills tutorials, extended curricula and internship programmes to provide assistance to students concurrent with their mainstream studies (cf Moulder [4] 6-7). Bridging or foundation courses focus on the provision of pre-degree assistance to educationally disadvantaged students, especially in science and engineering.

Selection of students for special mathematics programmes and courses

When presenting foundation or other special mathematics courses it is important to make sure that students are placed in an appropriate course or programme, to avoid frustration. A system needs to be in place, which evaluates students' skills and competencies properly. Students entering universities in South Africa could have completed their schooling in any of 9 provinces, each with its own final evaluation, so these alone are not an appropriate measure. The new higher Education Bill therefore makes provisions for universities to also have their own admission criteria.

South African universities are therefore developing their own admissions or placement tests. The philosophy followed at the University of Port Elizabeth is that the testing must look wider than skills and competencies in mathematics, because success depends also on other factors like language proficiency (English is the medium of teaching at UPE), study habits and non-cognitive factors. For this reason UPE has opted for a battery of tests including locally designed tests measuring language expression, non-cognitive factors, and non-verbal reasoning using the LOGO concept. In agreement with the USA Board of Colleges, components of the Accuplacer test are also used, including numeracy, algebra and language comprehension.

When dealing with the placement of students, important factors must be kept in mind:

(i) The test should serve as a placement mechanism and not as a barrier for entry. The tests should help to find a programme most suitable for each student's interests, skills and

competencies. This leaves the university with the challenge to provide such programmes, either on its own or in cooperation with other institutions.

(ii) Not all school leavers will necessarily benefit from studies at a university.

(iii) Testing tools used must be researched to establish their validity. A test used successfully at one institution or country will not necessarily be a valid predictor of success elsewhere.

Content and delivery mode of special mathematics programmes and courses

When designing a mathematics support programme, it is most important to remember that students have much more complex problems than specific mathematical content. A holistic approach should be followed which addresses not only the student's lack of mathematical knowledge. Attention must also be given to factors like language, life skills, study habits, etc. Students experience problems as a result of factors relating to the language of instruction, authoritarian teaching styles, and curricular content, which result in severe limitations in their study skills and processes (see [5] and [6]).

At a university like UPE, where a large number of new entrants to the university are first generation university students, and less than a third of all students are English first-language, these factors play a very important role in determining a student's success rate. Apart from factors outside of mathematics, experience in bridging programmes has clearly shown that mathematics content must be integrated with skills. This is illustrated clearly in the research on the successful Science Foundation Programme of the University of Natal (Pietermaritzburg, South Africa) (cf Grayson, [7]). Knowledge of specific mathematical calculations without the skill of using the calculations correctly at the appropriate time serves no purpose. Curricula must hence be designed to include cognitive skills like critical thinking, analysing, comparing, categorising and problem solving. These skills must however not be taught in isolation, but in context. This emphasises the importance of integration between different disciplines in a student's curriculum. Research has shown that very few people have the ability to transfer skills learned in one context to a different situation. (See [7]).

When deciding on the content and delivery mode for special support courses in mathematics, a distinction should be made between the pre-university foundation (bridging) course and an augmented or an adapted university course, because the two types of programmes have different aims. The aim of a foundation course is to prepare the student for studies in a degree programme or course needing mathematics as background knowledge. Students in such a course are typically those who have taken mathematics at school, but who failed or only just passed. The content of such a course will hence contain topics normally covered in the secondary school syllabus. The course must not be simply a repetition of the school syllabus. When selecting the topics from the school syllabus, the two main criteria should be:

(i) what content is an appropriate vehicle for teaching the skills mentioned above and

(ii) what content will the students really need in their future studies?

These points clearly indicate that it is not effective to simply work from a school textbook, which may also have a negative psychological effect on the students. Study materials should be developed specially for such a course, having a healthy balance between information given (not too detailed, as most of the work has been done before), sufficient exercises and additional

challenges. The specific balance between these things will depend on whether the course is presented through lecturer contact or through distance or semi-distance education mode.

The delivery mode for a foundation course must take cognizance of the low levels of mathematical understanding and knowledge of the students entering the course. It must hence start at a slow pace with lots of time for supervised practice and a lot of individual attention, but provide gradual transition towards students being given more responsibility for there own learning, to prepare them adequately for the challenges of a degree course. One way to achieve this is to move from small group tuition at the start to large group lecturing at the end, while more and more independent work are required from the student as the course progresses (CF Grayson, 1996, [7]).

The aim of augmented mathematics courses is to help students who have already been admitted to a main stream course, but who lack some necessary skills and competencies. Such students are typically those who only just managed to satisfy the standard admission requirement, or were admitted having just failed to meet these requirements. The content of such a course will be the same as for the corresponding main stream course with added topics to remedy a lack of pre-knowledge. In South Africa two different models are used for courses of this nature. In one, the duration of the course is the same as the corresponding mainstream course, but there are more contact hours per week (as at UPE). In others, the contact hours per week are maintained but the duration of the course is doubled (eg University of Pretoria). Different modes of delivery can also be used for these courses including distance and semi-distance education or even video teaching.

Special mathematics programmes and courses at UPE

Foundation Mathematics

A Foundation Mathematics course was introduced at the UPE in 1999. Its purpose is to prepare students for studies in directions needing a good mathematical background. The criteria used in the design of this course were:

- Skills needed by first year students to enable them to be successful in their degree studies. This includes much more than mathematical content, but general skills like problem solving, critical thinking, analysing, comparing and categorising. These skills were identified through series of workshops with academics. Specific content was included in the Foundation Mathematics course to be used as a vehicle for teaching these skills.
- Specific mathematical content that is regarded as essential pre-knowledge for studies in a variety of first year subjects was included. These topics were identified through questionnaires in which first-year lecturers in science and commerce courses were asked to identify the mathematics students need in their course.

Topics that were eventually included in the course are: Numeracy, Ratio and Proportion, Problem Solving, Basic Algebra, Introductory Trigonometry, Exponents and Logarithms, Introductory Calculus and Elementary Euclidean Geometry. The inclusion of Euclidean Geometry is an example of a topic that was included specifically to be used as a vehicle for teaching some of the skills mentioned above. This non-credit bearing course is offered to two groups of students:

- Degree students: students who satisfied all the admission requirements for a degree in commerce or science, except for the mathematics requirements, were given special admission on the condition that they upgrade their mathematics knowledge.

- University of Port Elizabeth Advancement Programme students: The UPEAP is a one year foundation programme for prospective commerce, science and pharmacy students who do not satisfy the normal requirements for admission to these degree programmes. The programme was presented for the first time in 1999 to a group of 101 students, almost all of whom are from previously disadvantaged communities having English (the medium of teaching in the programme) as a second, third or even fourth language. A holistic approach to the students' needs was followed in the design of the programme. An analysis was made of all the skills and competencies needed by a first year student and as many components of this was included in the programme. In the development of the curricula for the different courses a lot of emphasis was placed on skills development. Other special features of the programme includes the availability of a counsellor specifically for the students on the programme and courses in English communication, Computer Awareness and University Practice (the Life, Study, and Social skills needed by a student) in addition to the normal academic courses.

Supplemental Instruction

SI is a peer support system designed by the University of Missouri-Kansas City (UMKC). Totally separate from the lectures, trained SI leaders, senior students, supply additional support to first-year mathematics students. Students attend these sessions voluntary. SI leaders do not re-teach, but are supposed to use group facilitation skills to help students find solutions to problems for themselves. SI sessions are offered to students in all first year mathematics courses at UPE.

Video Supplemental Instruction

As with SI, VSI was developed at the University of Missouri-Kansas City, USA, as a means to prepare inner-city high-school students for challenging university courses (Martin & Arendale [8]). This programme has proved to be successful in that setting, with that aim in mind (see [8]), while some evidence exists of the effect of VSI on the academic performance of high-risk nursing students in Anatomy in South Africa (Nel, Beyleveld & Nel, 1996, [9]). In a VSI programme the normal lecturer is replaced by a series of videos made by a lecturer, with sessions guided by an experienced facilitator. A VSI project in which a Mathematics service course of UPE was presented to a group of specially admitted students at a Community college started 1998. A research report on the success of the VSI programme (Snyders [10] and Koch & Snyders, [11]) showed reasonable success, but further studies are necessary to determine its full impact in a South African context.

Augmented first year Mathematics Service Course

The same first year mathematics course that is presented in the VSI project is offered for full time students in a small group. Augmented course students are given more contact time with the lecturer (about 1.5 times that of main stream students). This creates the opportunity for working more slowly and doing more remedial work. The smaller group size also made for easier communication between the lecturer and students. Students in this group also had access to the same SI sessions as those in the mainstream course.

Conclusion

Within the reality of a constantly changing student population the challenge to provide quality Mathematics teaching to a diversity of students will increase in the new millennium. Universities will have to take more and more of this responsibility onto themselves. Universities cannot face this alone, however, and need the support of the government and private sectors, in particular, for the funding of these programmes.

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