THE IMPACT OF TWO-MODE MATHEMATICS CURRICULUM ON THE UNIVERSITY OF NAMIBIA FIRST YEAR MATHEMATICS STUDENTS

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ABSTRACT

Over the past decade, a continuous annual poor performance of the first-year mathematics students has been observed at the University of Namibia (UNAM) content knowledge among the majority of its mathematics first year students. The average pass rates of first-year students in mathematics are unacceptably low, which always falls below 50 percent. As an intervention to the low pass rate in first year Mathematics, the University has introduced a slow-streamed curriculum of mathematics, in which weaker students are permitted to do semester modules over a span of two semesters rather than the normal one-semester mode of study. This paper presents the findings of an analysis of the impact of the introduction of a slow-streamed curriculum of Mathematics at the University of Namibia. The findings of this impact study showed that since the introduction of the two-mode curricular system, the overall performance in the first-year mathematics has slightly improved.

Keywords: impact, slow mode, normal mode, performance, mathematics

1. INTRODUCTION

1.1 Admission requirements to UNAM

For one to secure admission to any of the science related programmes of studies, one must meet the minimum requirements of 25 points in the best 5[5] subjects passed at Grade 12 level, including English with at least a Grade C. All students in science courses are expected to take mathematics in the first year of their studies. These courses are Agriculture, Biological Sciences, Chemistry and Biochemistry, Computer Science, Mathematics and Science Education, Engineering, Geology, Health Sciences, Mathematics, Physics and Statistics. The first-year mathematics comprises of four different modules. These are: Basic Mathematics (in semester 1); Analytic Geometry (in Semester 1), Matrices & Complex Numbers (in semester 1); and Pre-Calculus (in Semester 2). Table 1 highlights the main mathematics content covered in each of the three modules.

Table 1: The mathematics content covered in the first year mathematics modules at UNAM

[5] In Grade 12, each student is expected to enroll for and write examination in at least six promotional subjects. However, when determining the overall pass grade for admission, only five out of the six subjects, in which the student has performed the best are considered.

Course Name	Description	Mark Allocation
Basic Mathematics **MAT3511**	• Sets: notation and diagrams to represent sets, subset, empty set, equality of sets, intersection, union, complement. • Algebraic expressions: simplification, expansion, polynomials, remainder and factor theorem, partial fractions. • Trigonometry: trigonometric functions, basic trigonometric identities, absolute value, linear equations, linear inequalities, quadratic equations, quadratic inequalities. • Functions: domain, co-domain, image, pre-image, even function, odd function. • Sequences: geometric sequence, arithmetic sequence, Binomial Theorem	50% CAS, 50% Exam
Analytic Geometry **MAT3501** Matrices and Complex Numbers **MAT3521**	• Points and lines in a plane: the distance formula, the triangle inequality, parallel and perpendicular lines, circles and tangent lines. • Conic sections: ellipse, parabola, hyperbola. Preliminaries to vectors. • Vectors in two and three dimensions: addition of vectors, multiplication by a scalar, magnitude, dot product, cross product. • Complex numbers: operations on complex numbers, the complex conjugate, Argand diagram, modulus-argument form, de Moivre's formula, fundamental theorem of algebra. • Matrices: addition, multiplication, scalar multiplication and transpose (for up to 3×3 dimension), determinant and inverse (with emphasis on 2 × 2), solutions of systems of linear equations by Cramer's rule (for 2 × 2), and by Gaussian elimination method (for up to 3 × 3 matrices).	
Pre-Calculus **MAT3512**	• Functions: one-to-one and onto functions, horizontal line test, composition of functions, inverse of a function. Introduction to exponential and logarithmic functions. • Limit of a function: definition, left and right limits, improper limits, continuity in terms of limits. • Differentiation: rate of change, derivative of a function, rules of differentiation, increasing and decreasing functions and graph sketching. • Integration: anti-derivatives, the definite integral, area under a graph. • Trigonometry: area of a sector and segment of a circle, further trigonometric identities, trigonometric equations, derivatives and integrals of trigonometric functions.	

1.2 Background to the study

Mathematics failure rates at the University of Namibia, especially among first year modules, have been extremely high for the past ten years (Miranda & Gideon, 2011). The majority of the students are not able to cope with mathematics content in these modules. In most cases, students carry on to the third year with first-year course work of the mathematics modules lagging behind. In response to this problem, a research group was formed by the current authors in 2010 in order to conduct focused research studies from different angles and come up with possible solutions as to how the situation could be improved.

Initially, an analysis of the students' performance in first year mathematics between 2009 and 2010 was done in order to determine which areas they were performing the poorest (Miranda & Gideon, 2011). This marked the first research study of the project aimed at understanding the factors underlying the problem of high failure rates in first year mathematics modules at te University of Namibia. From the analysis, it was found that a high percentage of students demonstrated great weakness in understanding concepts such as: polynomials, sets, partial fractions, absolute value, inequalities, functions, and sequences in Basic Mathematics; conic sections, vectors, matrices, systems of linear equations, Cramer'srule, Gaussian elimination, and complex numbers in Analytic Geometry; and one-to-one functions, composite functions, inverse functions, limits of functions, differentiation, increasing and decreasing functions, integration and application of calculus in pre-Calculus.

The second research study (Miranda & Nakashole, 2012) addressing the problem of high failure rates in mathematics was a curriculum analysis of the Namibian mathematics curriculum from Grade 0 to Grade 12. This study was done with the main purpose of analyzing coherence in the school mathematics curriculum and to determine how the curriculum prepares the learners for university mathematics. Apart from the gaps that were identified in the school mathematics curriculum, with regard to the coverage of common themes in mathematics, it became evident that most of the content that is supposed to equip students with the basics required for first year university mathematics are not covered in the current National Secondary School Certificate mathematics curriculum (Ministry of Education, 2007, 2010).

The third research study, which is still on-going, is a comparative study, in which the Namibian school mathematics curriculum is compared with curricula from two other African countries, South Africa (Department of Education, 2002, 2003) and Zimbabwe (ZIMSEC, 2008, 2012) and one developed country, Alberta, Canada (Alberta Education 2007, 2008). Preliminary findings from this phase of the project suggest that even though the Namibian school mathematics curriculum has many themes in common with all the other countries' curricula, the depth at which these themes and their topics are covered is quite shallow as compared to the others.

The fourth research study, which is still in its early stages, is focused on understanding the possible factors that might be contributing to the high failure rates in mathematics at the university (Miranda, Dzambara, & Ilukena, 2012). This is specifically to investigate aspects such as teaching approaches, assessment as well as students' perceptions of the concerned modules with respect to how students view the modules and their performance per se.

In addition, to the various analyses that have been done and those that are still continuing, the Department of Mathematics at the University of Namibia has introduced a two-mode curricular choice that students in year one can make use of. In this system, students are allowed to complete each of the first-year modules as either semester modules (normal mode) or as full-year modules (slow mode). The selection of students into either the regular or the slow-streamed curriculum is based on a mid-term entry test in Basic Mathematics that they write during the first semester. A

student achieving 40% or above in that test is allowed to complete Basic Mathematics and all other first year mathematics modules in one semester (normal mode). Whereas, a student achieving less than 40% in the entry test can only do all his/her Mathematics modules over a span of two semesters (slow mode).

1.3 Statement of the problem and significance of the study

Since the introduction of the two-mode curricular option, no empirical analysis was conducted in order to determine whether the option has any impact on the students' performance in first-year mathematics. Therefore the main purpose of this research study was to conduct an initial analysis on the impact that the two-mode curriculum might be having on students' overall performance in first year mathematics. The research is therefore aimed at determining the impact (if any) the introduction of the two-mode curriculum at the University of Namibia has on students' performance in first-year Mathematics.

This analysis is very important because it informs the department in particular and the University in general, in decision-making regarding whether the two-mode system should be maintained as well as on any further improvements that may be required. The study further informs the other research studies that are being conducted in the university that in order to address the issue of high failure rates in mathematics.

2. LITERATURE REVIEW

Salma, Esere, Omotosho, Abdullahi and Oniyangi (2011) observe that "the trend of poor academic performance in Mathematics by students appears a global issue" (p. 2713). Moreover, difficulties with mathematics and poor performance manifest themselves across all levels of the curriculum—from primary, through secondary to tertiary levels of studying mathematics. Different factors that research has consistently linked to the poor performance in mathematics are such as anxiety (Witt, 2012), lack of understanding and inability to see the applicability of mathematics (Kalloo & Mohan, 2012) and many more. Investigating the various factors associated with poor performance in school mathematics and physical science in South Africa, Mji and Makgato (2006) found out direct and indirect factors that could be linked to the poor performance. Direct factors included teaching strategies, content-knowledge and understanding, motivation and interest, and syllabus non-completion. They also identified indirect factors such as language and parental role (in case of young learners).

The current study addressed the factors that are directly related in terms of non-completion of the syllabus. Although lecturers manage to cover the stipulated content in each of the three modules, to the students who are slow at mastering this content, the curriculum has not been completed since they do not get ample time to grasp the key concepts of the subject. The study was

therefore interested in determining the extent to which an extended period of coverage of the module has an effect on student academic performance in the concerned mathematics modules.

While acknowledging that since students transiting from high school to university, experiencing university mathematics for the first time are obviously likely to encounter some difficulties with the new content, (De Vleeschourver, 2010) points out that such difficulties "can also be caused by the possibility that the same mathematical notion will be approached differently in the secondary school institution and in the undergraduate institution" (p. 155). De Vleeschourver, further argues that since some of the difficulties that students encounter at first-year level mathematics are more global, e.g., confusing terms or concepts, freshmen mathematics candidates do not possess the skills of writing formal mathematics. Therefore continued analyses on difficulties experienced by students in first year mathematics is required in order to "provoke ideas towards designing new teaching approaches that could help to overcome these difficulties" (p. 169).

Iipinge (2012) investigated the perceptions of the first year mathematics students at the University of Namibia in the same modules that this study is concerned with. In her analysis, IIpinge showed that more than 70 percent of the first year mathematics students agreed that the slow mode of the curriculum allowed them enough time to cover the content of the module. Further, the students saw first-year mathematics an integral part of their transition to university because they see it as a bridge between high school mathematics and university mathematics. Another finding of Iipinge's study is that students felt that the slow mode of the mathematics curriculum helps in reducing their anxiety towards mathematics.

Jungic (2006) identifies challenges, offer constructive help and share useful technigues for teaching large classes. These classes are considered to be more than 350 students and offered by a single instructor. In this paper the issue of preparation, organization, course administration, instruction, use of technology, student management and grading has also been upacked.

The literature reviewed regarding the high failure rates in mathematics in Namibia and beyond calls for the need for more focused research analyses on the conditions required for improved mathematics instruction at all levels of mathematics study. Apart from all the research projects that the research team at the University of Namibia is embarking on with the aim of pointing out possible solutions to the problem, the university, through the department of mathematics has put in place an intervention of the two-mode curricular system. However, there have not been systematic analyses on the impact of this intervention programme on the students' performance in first-year mathematics performance.

3. THE TWO MODE SYSTEM MODEL

The Department of Mathematics is committed to addressing the matter of very low pass rates and big classes at the first year level in the mathematics modules. As indicated earlier, the modules

being offered at first year are: Basic Mathematics, Analytic Geometry, Matrices and Complex Numbers, and Pre-Calculus. Due to the higher failure rate and also big classes in first year a decision was made to introduce a two mode system in first year mathematics. In addition, other measures such as subdivision of tutorial classes into smaller groups and also introducing tutorials as practicals were among the solutions that were considered ideal to influence human interaction in this situation.

3.1 Placement of the students

The two mode system is envisaged to address big classes, and low pass rate in the first year mathematics and also improve students – lecturer interaction. In the beginning of the year the university receives about 1500 students in the first year mathematics, with about 1100 situated on the Windhoek Main Campus. The others are enrolled in the Khomasdal, Rundu, Hifikepunye Pohamba, Katima Mulil, Ogongo and Neudam Campuses. All students are normally taught under the same system for about two months and then be given the same first test in Basic Mathematics. This serves as a yard stick for the selection of the students. The system has been running as follows:

1) Students are selected based on the results of the first test in the Basic Mathematics module.
2) Any student with a mark less than 40% is placed in the slow stream; by which is meant the student will be taught each of the 1st year mathematics courses over two semesters (instead of one semester).

3.2 Lectures and tutorials

For a long while the mathematics classes at first year level at UNAM have been too big to handle. The university has decided to employ technologies to address the teaching of big classes but this has proven to be of very little help. In case of big classes, the classes are subdivided into smaller groups of about 350 students and to which senior staff of the Department are allocated. For technology integration, it has been recommended that the staff should use overhead projectors alongside the newly introduced smart board system. The reason for this is that it is easier for the students to follow the working of a given concept of problem when the lecturer is writing out the steps, than merely presenting pre-written material in form of power point, for example.

In the same effort tutorials are handled as practical sessions running from 14h00 to 16h00 every afternoon during the teaching week. Each tutorial class has at most 80 students. This provides students with more time to interact with their tutors. Further, the students are encouraged to solve the tutorial worksheet problems before they attend their respective practical sessions. On the Windhoek Main Campus, the Department has eight tutors in its staff complement, and each of

the tutors contacts at least one practical session per week in each of the first year mathematics modules. During a given practical session, the tutor is not supposed to provide complete solutions to the worksheet for the students but rather give directions on how a particular question should be handled. One must quickly point out here that the satellite campuses do not have the tutorial support as in the case of the Main Campus.

The lectures and tutorials for these two different systems are separated and handled differently. The lectures for the different modes are also offered by different lecturers. In each tutorial, the class is assigned two student demonstrators/assistants from the third and fourth year level in mathematics. These work under the supervision of the tutor assigned to the particular class.

3.3 Assessment and Evaluation

Students are assessed separately based on the nature of the two modes. Students who are doing the normal mode are assessed over a semester and those that are doing the slow mode are assessed over a year. In this regard, students on the normal mode are given three major tests of which two best tests will form part of the 70% towards the continuous assessment. The other 30% percent comes from the short tests offered during the practicals (formerly known as tutorials). In this case students write one short test per week and the student demonstrators mark this test and record the marks as such. A student can only be allowed to sit for the final examination if he/she has obtained a continuous assessment of 40% or above on either mode. The students on the slow mode are given up to 6 major tests, and it is usually up to the discretion of the Department, through the course coordinator, to decide on the number of short tests to consider for the continuous assessment.

3.4 Examination

Students on the normal mode write their final examination at the end of the semester while those on the slow mode write the examination at the end of the year. The examinations for the two separate modes are not the same but the assessment covers the same content and the same weight of marks. The final mark a student obtains towards their grade for each of the courses is computed as the average mark between the continuous assessment mark and the examination paper mark.

3.5 Student Consultations

On the Main Campus, the Department has designated one big office enough to accommodate two tutors. In this office there should be someone to attend to the students and this platform addresses the lack of human interaction which is not feasible during the normal teaching time. Students are

expected to solve their problems before they come for consultations. In the same spirit, lecturers are also expected to put up consultation hours on their office doors.

3.6 The Modules

As indicated in Table 1, the Department is offering three modules in first year mathematics, i.e. Basic Mathematics, Analytic Geometry, Matrices and Complex Numbers, and Pre-Calculus. The first two modules are offered in the first semester while the Pre-Calculus is offered in the second semester. This is only applicable to the students doing the normal mode. In an event of students doing the slow mode, the students have to do the first two modules for the whole year and then take Pre-Calculus in their second year of registration.

3.7 Students

Most of the new students come to the university with a weak background in mathematics as they are not exposed to the extended mathematics syllabus at high school level. Further, it has also been observed that even some of those students who have taken the extended mathematics syllabus at high school and passed with A's and B's perform badly in first year university mathematics. Only students who did high school mathematics at the higher level tend to pull through successfully.

3.8 Textbooks

In each of the courses, the Department prescribes the relevant textbooks, and it has also encouraged staff members to develop study guides and upload them on the student portal.

3.9 Assignments

The Department does not hand out homework assignments for grading because the majority of the students have been in the habit of copying from each other. Rather, the Department has resorted to giving short tests every week during the last 15 minutes at the end of every practical session. This strategy seems to be more effective as each student is expected to attend one tutorial session a week.

3.10 Student Portal

Student portal has proven to be the most suitable platform for student interactions. Lecturers upload documents such as tutorials, solutions and many other announcements. One ideal aspect about this platform is that students can access it even from home.

4. METHODS AND FINDINGS

4.1 Overall performance before and after the intervention

The data collected for the study with regard to the number of students enrolled for the three first-year mathematics modules, the number of those who qualify to sit for examination and those who pass the modules have been gathered as from the year 2008. The raw information has been obtained from the Examination Office of the University of Namibia, on an annual basis. The data on performance for the three years (2008, 2009 and 2010) before and after the implementation of the two mode system are presented in Figure 1 (Basic Mathematics), Figure 2 (Analytic Geometry, Matrices & Complex Numbers) and Figure 3 (Pre-Calculus).

Figure 1: Annual Performance in Basic Mathematics, 2008 - 2012

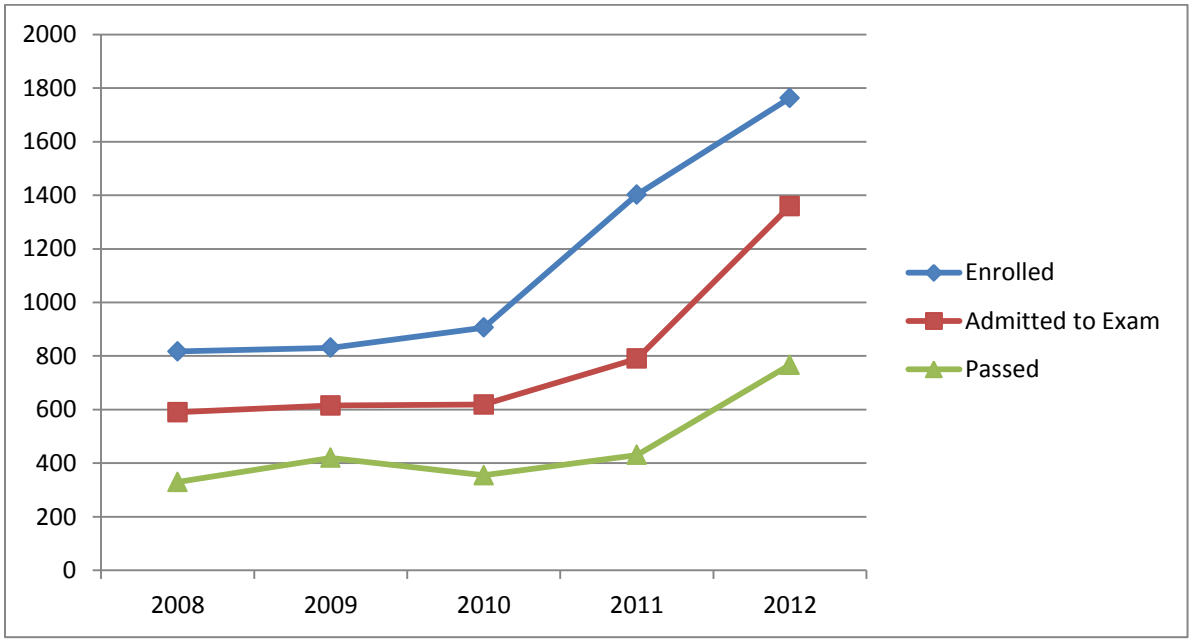


Figure 2: Annual Performance in Analytic Geometry, 2008 - 2012

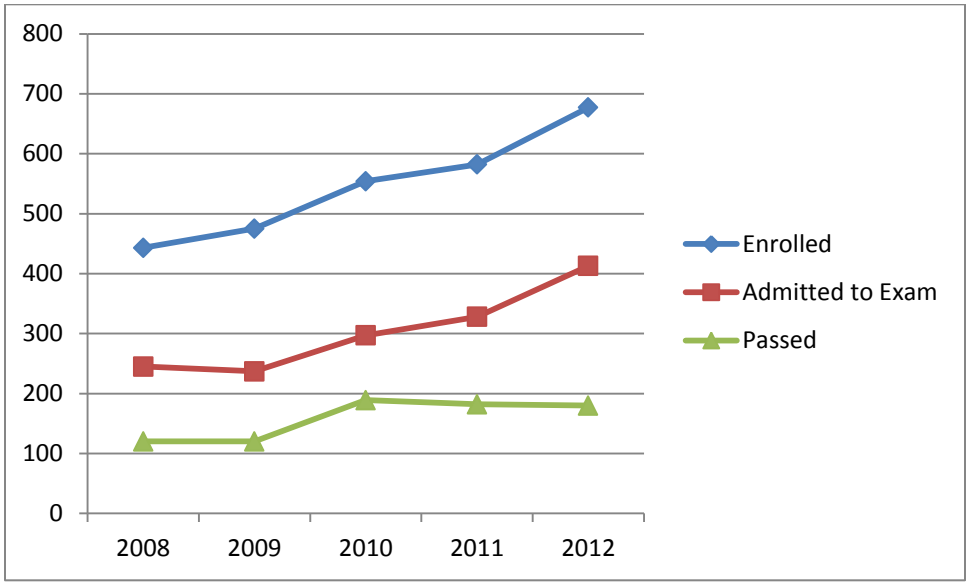
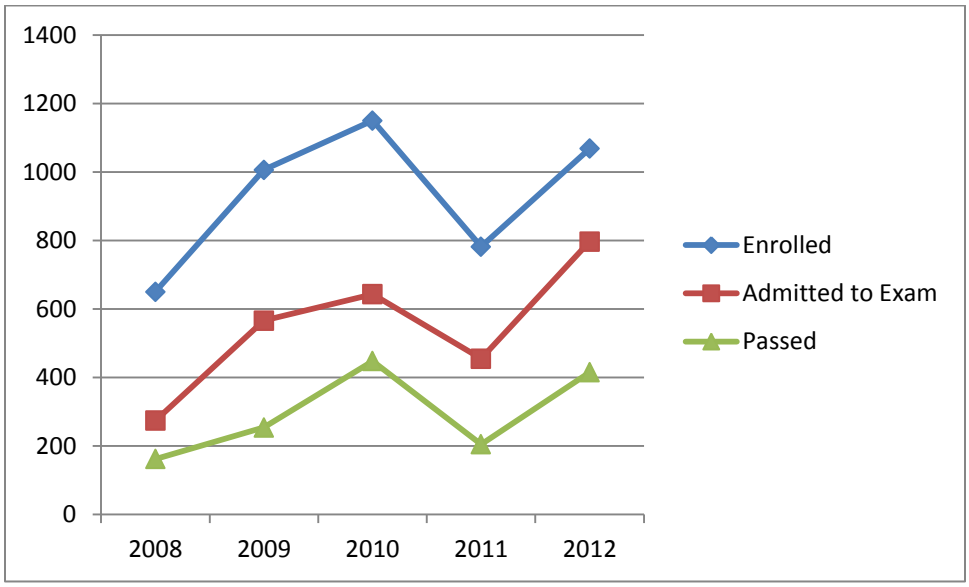


Figure 3: Performance in Pre-Calculus, 2008 - 2012



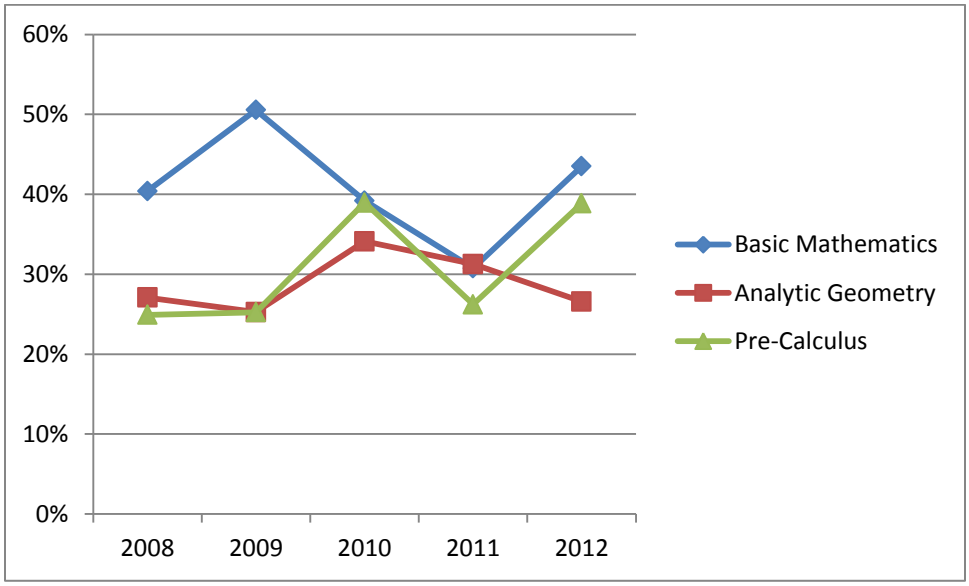
It can be seen from the graphs that the number of students enrolled in the first-year modules has increased with each year, not because the university admits more students than the previous years but because every year there are more students repeating the first-year modules due to the high failure rates. The graphs above do not really say much about the improvement or drop in the annual performance of the three modules for the three years, 2008, 2009 and 2010. However, they do indicate that not all students enrolled in the three modules get admission to the

examinations, and a few of them pass the modules. Also while the number of students who passed Basic Mathematics went down in 2010, the number of students who passed Analytic Geometry and Pre-Calculus increased each year.

One possible explanation for the drop in the performance of the three modules in 2011 could be the fact that this was the first time the two-mode curriculum was introduced. There might be a number of factors that both lecturers and students had experienced and hence in the process affecting the performance. Overall, the number of students passing first-year mathematics has gone up since the introduction of the two-mode system.

The graph below, in Figure 4, illustrates the percentages of annual pass rates in the three modules both before the intervention (2008-2010) and after the intervention (2011-2012).

Figure 4: Overall Annual Performance Rate (in percentages) in the three modules



It is evident from Figure 4 that since the intervention (i.e. the introduction of the two-mode mathematics curriculum), the overall performance in the three first-year mathematics modules has improved. As explained earlier, there is a relative fall in the performance in all the three modules, in 2011. Even though the performance in Pre-Calculus has dropped lower than the other two modules, in the year 2011, it picked up slightly in 2012. Unlike in Basic Mathematics and Pre-Calculus where improvements can be seen, the performance in Analytic Geometry, Matrices and Complex Numbers has been low since the introduction of the two-mode curricular system. Of all the three modules, Basic Mathematics has improved the most in pass rate.

The analyses above highlight the overall performance in the three modules for all students (both normal mode and slow mode). Therefore a comparative analysis is needed in order to separately

show the trends in performance in the three modules for each mode of study. This is done the following section.

4.2 Normal mode-slow mode comparisons

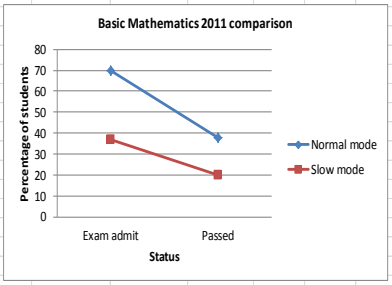
Figure 5 below presents a much bigger picture of how the performance in the three modules of mathematics can be compared with one another since the introduction of the two-mode curriculum system.

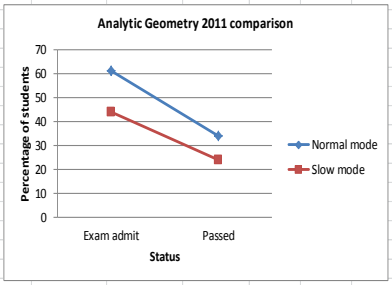
Figure 5: Normal mode-Slow mode Comparisons (2011-2012)

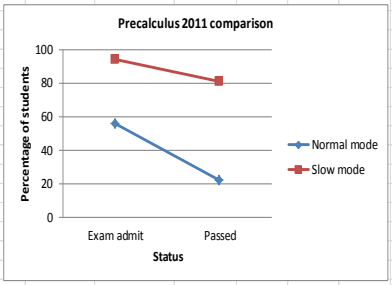
	Basic Math		
2011		Exam admit	Passed
	Normal mode	70	38
	Slow mode	37	20
2012		Exam admit	Passed
	Normal mode	87	53
	Slow mode	56	24

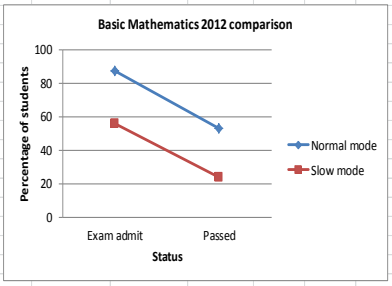
	Analytic Geometry		
2011		Exam admit	Passed
	Normal mode	61	34
	Slow mode	44	24
2012		Exam admit	Passed
	Normal mode	67	33
	Slow mode	42	8

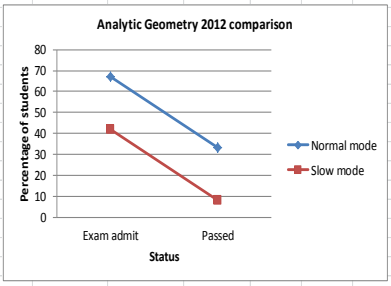
	Precalculus		
2011		Exam admit	Passed
	Normal mode	56	22
	Slow mode	94	81











Looking at the graphs in Figure 5, one cannot help but notice the remarkable improvement in performance in Pre-Calculus in 2011. This is evident from the shape of Pre-Calculus graph which is less steep than the graphs for Basic Mathematics and Analytic Geometry, an indication that the fall between the number of students qualifying to sit for the examination and those who passed the examination is not as big as in the other two modules. In particular, the percentage of students who qualified to sit for examinations and those who passed the Pre-Calculus slow mode is more than that of the students in the fast mode.

For all the three modules, the pass rates for slow and normal modes are comparable, but taking into consideration that students following the slow mode are weaker, it can be argued that the slow mode has produced good results.

5. CONCLUDING REMARKS

It is still very early to confidently conclude that the introduction of the two-mode curriculum in the first-year mathematics at the University of Namibia has had an impact on students' academic performance. However, taking into consideration the fact that the intervention was only introduced in 2011, it is obvious that the performance has improved in 2012. Major improvement can be seen in the Pre-Calculus slow mode in comparison with the normal mode. More time (two to three years) is still needed to consistently monitor the impact that the two-mode curricular system is having on students' performance. In future a comparative analysis is needed in order to separately show the trends in performance in the three modules for each mode of study.

6. WAY FORWARD

As a way forward, the research team involved in various projects addressing the issue of high failure rates will continue with its investigations in order to come up with empirical evidence that may explain the shortfalls in the concerned modules. In addition, the Department of Mathematics plans to make some adjustments to the administration of the normal and slow modes of the first-year mathematics modules. For example, the entry requirements for selecting students into slow vs. normal modes need to be revisited. The slow mode of the Pre-Calculus is usually done in the first semester of the second year, affecting students' registration in other modules of their studies. This might need to be incorporated into the first year of registration with the other two modules.

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