



PRESENTING FIRST YEAR MATHEMATICS IN THE ALTERNATIVE SEMESTER – A WORTHY EFFORT

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ABSTRACT—This paper reports on a worthy effort to improve the throughput rate in first year mathematics at the University of Johannesburg. Presenting first year mathematics in the alternative semester (introduced in 2010 for the first time) provides students with multiple opportunities; firstly to contribute towards the throughput rate, secondly to improve their mathematical proficiency (knowledge and skills) and thirdly to develop their learning skills. The overarching research aim is to investigate the influence of an alternative semester programme on the mathematical proficiency of a group of first year students and to reflect on the development of students' self-regulated learning skills by means of the specific mode of teaching. The influence of teaching approaches on students' mathematical proficiency is highlighted by research (Boaler, 2002; Samuelsson, 2010). Keeping in mind that the mode of teaching seems important for the development of students' mathematical proficiency, we introduced a unique teaching style. Student feedback was collected via a formal survey and final marks were analysed. The sample consisted of a group of 102 first year mathematics students in the Faculties of Science and Engineering. The valuable nature of student feedback provided verification for the continuation of the alternative semester programme. Noticeable dividends from the programme are perhaps the positive influence on students' self-regulated learning skills together with the improvement in mathematical knowledge and skill.

Keywords: Mathematical Proficiency; Throughput Rate; Learning Skills; Teaching Styles.

1. INTRODUCTION AND PURPOSE

Poor academic performance in first year mathematics and high dropout rates for first year students at universities have been a point of discussion by researchers over the past decade (Rylands & Coady, 2009; Van Zyl, 2010; Yates & James, 2007). Higher education institutions investigated possible ways of supporting students in the first year at university as “student throughput and retention is fundamental to the continued existence of universities” (Davis & Venter, 2010, p. 82). Research by Samuelsson (2010) indicates different factors contributing towards students' mathematical proficiency. It seems that the influence of teaching (the teacher or lecturer) plays a role in the development of mathematical proficiency.

In particular at the University of Johannesburg (UJ) in South Africa, presenting first year mathematics in the alternative semester provided an opportunity to support first year mathematics students. Previously, students were supported by the offering of so called limited contact courses (presented on selected Saturdays). Due to various factors like logistics, limited contact time and others these courses were replaced by the more effective alternative semester offerings. This paper thus focuses on a core issue of the higher education teaching and learning setting. Its purpose is to investigate the influence of an alternative semester programme on the mathematical proficiency of a group of first year students and to reflect on the development of students' self-regulated learning skills by means of the mode of teaching.

2. CONTEXT OF AND RATIONALE UNDERLYING THE RESEARCH

In 2010, the Department of Mathematics at the UJ implemented a supplementary teaching strategy in an effort to increase the low throughput rate of first year students in mathematics. This strategy



involved the presentation of some mathematics courses (specifically first year Calculus) in the alternative semester. As a result, students who failed first year Calculus in the first semester can repeat the same course in the consecutive semester and eliminate the implication of failing courses (extension of the period of study). Since mathematics is a prerequisite for various degrees and qualifications offered at UJ, it is beneficial to all stakeholders (students, faculties and the university) to improve the throughput rate in these courses.

The throughput rate for first semester Calculus (MAT1A10) in 2010 was 43% and for both courses together (MAT1A10 & ASMA1A1) it was 62% at the end of the second semester, after the offering of the alternative semester course. According to these results 328 students passed MAT1A10 and a total of 478 students passed overall including ASMA1A1. This means that an additional 150 students were provided the opportunity to pass the module in 2010. Similar results from 2011 indicate a 41% throughput rate for MAT1A10 and 53% for MAT1A10 and ASMA1A1 together. Again, this means an additional 101 students passed the course in 2011. These throughput numbers since 2010 indicate the continuation of alternative semester presentation for Calculus courses and this option can be implemented in other courses and by other universities as a measure to improve throughput.

At UJ, alternative semester courses for first year mathematics are offered in the same time periods as the main stream courses and therefore fit the students' timetables. The following table provides an overview of the course structure.

Table 2. Main stream and alternative semester course structures for first year mathematics

Module	Subject Code		Semester of offering	
	Main Stream Code	Alternative semester code	Main Stream	Alternative semester
Calculus of one variable functions	MAT1A01	ASMA1A1	1 st semester	2 nd semester
Applications of Calculus	MAT1B01	ASMA1B1	2 nd semester	1 st semester

From the table it is evident that not only first year, first semester Calculus (MAT1A01) is offered as an alternative semester course in the second semester of the same year, but the first year, second semester Calculus course (MAT1B01) is also offered as an alternative semester course in the first semester of the second year. Corresponding data provide evidence for the increase in throughput numbers for this course.

Since 2010, the lecturer for the alternative semester courses (experienced in the teaching of Calculus) recognised the necessity for these courses and the obligation that lies with the teaching. She came to the realisation that a different approach in teaching is required to support these students who had already failed their first semester at university. The specific mode of teaching to improve the mathematical proficiency and self-regulated learning skills of these students, form the focus of this paper.

3. LITERATURE PERSPECTIVES

3.1. Theoretical Framework

A theoretical framework refers to the philosophical basis of the research in order to form a link between the theoretical and practical aspects of the inquiry (Bless, Higson-Smith & Kagee, 2006). Such a framework supports the methodologies and methods which were used and provides reasoning for the selection thereof. The methodologies are meant to generate a satisfactory answer(s) to the research question (Creswell, 2013). The researchers' knowledge claims and theoretical perspectives justify the methodology used.

The primary theoretical lens that underlies the inquiry is the "curriculum-as-practice" framework that claims that educationists need to focus on practical interest through various kinds of interactions (Lockett, 2006). In this paradigm, students' understanding, thinking and reflective

processes are the central focus of any curriculum. It does not mean that stated learning outcomes are not important, but “...rather that they are secondary to the learning processes of achieving them” (Lockett, 2006, p. 80). The curriculum-as-practice paradigm gives emphasis to the environment in which learning occurs and places responsibility for learning on the shoulders of both teachers (lecturers) and learners (students).

3.2. The determinants of mathematical proficiency and the influence of teaching methods

From a research perspective mathematical knowledge comprise of much more than the concept of numbers and operations with numbers. Viewpoints from Kilpatrick, Swafford and Findell (2001) supported by Samuelsson (2010) define five different strands of mathematical knowledge, which as a combination indicate students’ mathematical proficiency. These strands include; (1) *conceptual understanding* (grasp of mathematical concepts, operations and relationships), (2) *procedural fluency* (the skill in performing flexible procedures accurately, efficiently and appropriately), (3) *strategic competence* (the ability to formulate, represent and solve mathematical problems), (4) *adaptive reasoning* (the capacity for logical thought, reflection, explanation, and justification) and (5) *productive disposition* (to view mathematics as sensible, useful and worthwhile with a belief in self-confidence) (Samuelsson, 2010, p. 62).

A limited number of studies focus on how different teaching methods affect students’ mathematical proficiency and self-regulated learning skills. Related studies show that diverse teaching approaches influence the outcomes for students in different ways. Samuelsson (2010) argues that inviting teaching approaches, such as encouraging cooperation with classmates and lecturer, give students additional opportunities to understand and succeed. Research by Boaler (2002) highlights the importance of certain aspects in the development of flexible mathematical knowledge such as working through textbook exercises, but on the other hand this approach can limit students’ to apply mathematics. Samuelsson (2010, p. 63) indicates the research by Boaler gives evidence for the theory that “context constructs the knowledge that is produced.” The development of mathematical proficiency through teaching is therefore somewhat determined by a variety of opportunities to learn. According to other research in America and Brittain (Reynolds and Muijs, 1999) improvement in mathematical proficiency is substantial when lecturers create classrooms that include certain features like significant emphasis on academic instruction and students’ engagement; whole-class instruction; effective question-answer and individual practices; minimal disruptive behavior; high teacher expectations; and substantial feedback to students.

Mishra (2007) argues that a lecturer (teacher) can only determine whether the students understand a concept by interacting with the students. Interactive teaching aims at empowering students to be independent learners as it implies in the first place that students are involved in more than listening, secondly less emphasis is placed on transmitting information and more on developing students’ skills and in the third place students are involved in higher-order thinking. Clearly, the mode of teaching in mathematics seems to be essential for students’ development of mathematical proficiency.

3.3. The teacher (lecturer) factor as a determinant in mathematical proficiency

A study by Lazarides and Ittel (2012) confirms the firm relationship between negative views of the so-called “teacher’s factor” (Maat & Zakaria, 2010, p. 16) and negative attitudes towards, low self-concept and a lack of interest in mathematics. The visible contribution of the ‘teachers’ factor’ to student learning of mathematics is established by a broad scan of the literature. This factor can include a lecturer’s personal qualities, beliefs, values, attitude, knowledge of mathematics, teaching-learning philosophy and methodology, devotion to her/his educational role, interest in and relationship with students, the establishment of a conducive environment and several other aspects. Researchers who conduct on-going studies on the relationship between mathematics teaching and student learning, attitude, motivation and achievement (Dowker, Ashcraft & Krinzing, 2012; Maat

& Zakaria, 2010) agree when they highlight desirable features of an effective teacher's factor in action; (1) shaping positive student expectations in respect of mathematics learning; (2) setting reasonable challenging meaningful tasks; (3) engaging students in regular mathematics learning and practicing, followed by frequent constructive feedback; (4) creating teaching-learning situations that promote student motivation, attitude, ability, confidence, self-concept, interest and pleasure in respect of mathematics; (5) establishing and maintaining a supportive and conducive teaching-learning environment and climate, characterised by a high level of clarity, effective management, structure, regular student-lecturer interaction and caring, observant and approachable teacher (lecturer) behaviour; and (6) taking into consideration how students perceive and assess the effectiveness of teaching, their own learning and the nature of the teaching-learning environment, and constructively acting upon it.

Students who hold more positive perceptions of their teachers (lecturers) have a more constructive attitude towards mathematics (Maat & Zakaria, 2010). The contribution of the 'teachers' factor' to student learning of mathematics clearly stems from the referred literature and cannot be underlined sufficiently.

3.4. First year students' self-related learning skills as determinant in successful academic performance

A research project conducted at UJ by Van Reenen, Pretorius and Snyman (2006) points out specific needs for first year students to achieve academic success. These needs are not only desirable, but essential to prevent high dropout rates. Results indicate that the highest need by students in an academic context is the mastering of effective study skills and the increase in self-motivation from an emotional point of view. A broad study of other literature perspectives indicate that students' self-regulated learning skills such as interest, view of the subject's importance, self-perception and attribution are influenced by different teaching methods (Boaler, 2002; Sameulsson, 2010). Students who are expected to cram for examinations describe their attitudes in passive and negative terms in contrast with the positive attitudes of active students who contribute ideas and methods. In a discussion from Bass (2008) mathematics students require study skills like time management, being disciplined and deliberate in actions. Undoubtedly effective study skills in mathematics contribute towards academic success in first year courses.

3.5. Summary of the theoretical framework

The following issues, underlined by the abovementioned theoretical framework, have specific applicability in this study:

- students' mathematical proficiency can be influenced by the mode of teaching;
- students' mathematical proficiency related to their needs and self-regulated learning skills; and
- effective, dedicated and thoughtful mathematics teachers (lecturers) play a substantial role to student learning of mathematics.

4. RESEARCH DESIGN AND METHODOLOGY

4.1. Research paradigm and methodology

The relevant research paradigm underlying this inquiry is *Pragmatism* (Creswell, 2013) as these knowledge claims strongly build on the curriculum-as-practice theoretical framework for the study (compare section 3.1). Pragmatic knowledge claims focus on a solution to a problem as these claims arise "out of actions, situations, and consequences rather than antecedent conditions" (Creswell, 2003, p. 11). The research problem "What influence might an alternative semester programme and the mode of teaching have on the mathematical proficiency of a group of first year students?" is influenced by several determinants and Pragmatism allows multiple methods. A *sequential mixed-methods* approach, including both quantitative and qualitative data collection methods, (Creswell, 2013) was applied. In this enquiry the quantitative data was collected first and secondly the

qualitative data. By this approach the researchers seek to elaborate on the findings of the quantitative data.

4.2. Sampling and unit of analysis

A purposive sampling method (Babbie, 2015) was adopted in both data collection phases of the study. Purposive sampling allowed the researchers to select both class groups (samples) according to the nature of the problem and the phenomenon being studied. For the quantitative data collection phase the unit of analysis were 665 first year students in the Faculties of Science and Engineering enrolled for Calculus (MAT1A10) at UJ in the first semester of 2014. The unit of analysis for the qualitative data collection phase was 102 students in the Faculties of Science and Engineering enrolled for the alternative semester course (ASMA1B1) in the first semester of 2015.

4.3. Data collection and analyses

4.3.1. Quantitative data

To compare the throughput records of students registered for MAT1A01 and ASMA1A1 + MAT1A01 in 2014, final marks (including semester and examination marks) of the 665 students enrolled for MAT1A01 were interpreted. The Excel statistical package was used to conduct the analyses.

4.3.2. Qualitative data

Towards the end of the first semester in 2015, individual student feedback on their live course experiences were collected via a semi-structured open-ended questionnaire. The group of students is defined by variety of characteristics; gender (29% female and 72% male), ethnical classification (9% Asian, 62% Black, 8% Coloured, 18% White and 4% other), home languages (8% Afrikaans, 32% English, 58% Indigenous and 3% European) and with an average age of 20 years. The majority of the students in the sample group obtained a mark between 60% and 69% in Grade 12 mathematics. The 102 students registered for ASMA1B1 were collected from students who either passed MAT1A01 (but failed MAT1B01) or students who failed MAT1A01 and passed ASMA1A1. Individual feedback per category was consolidated and then analysed via the constant comparative qualitative research methodology, as a directed form of content analysis (Hsieh and Shannon, 2005). Appropriate student views, by quoting their direct words are integrated into all categories of feedback in support of the findings. The following table provides an overview of the characteristics of the students involved in the study.

Table 2. Biographical information of the sample group (N=102)

Gender	Female	29
	Male	72
	No response	1
Ethnical classification	Asian	9
	Black	62
	Coloured	8
	White	18
	Other	1
	No response	4
Home Language	Afrikaans	8
	English	32
	Indigenous SA	58
	European	3
	No response	1
Mark interval for Grade 12 mathematics	80%+	6
	70-70%	32
	60-69%	43
	50-59%	19
	No response	2

4.4. Trustworthiness, validity and reliability and ethical considerations

Strategies to maintain the *trustworthiness* of the qualitative aspects of the study included selected measures of the four constructs credibility, transferability, dependability and confirmability, originally mentioned by Lincoln and Guba (1985). A thorough description of the mode of teaching in the alternative semester course is seen (to enhance transferability) and the methodology employed (to promote dependability and rigour). The credibility of the research is strived for through a proper interrogation of the analyses and findings and records of these have been kept for further referral. In respect of *validity* and *reliability* of the quantitative aspects of the study, the official student marks have a strong nature and is regarded as valid. Additional *reliability* measures were therefore not regarded as necessary.

In order to maintain individual confidentiality, participants were assured that any information revealed from the questionnaires is recorded in an anonymous manner. Participants were also informed that their participation and involvement were voluntary and at any time, should they feel uncomfortable, they had the right to withdraw from the study without prejudice to them. Written consent was obtained from all participants via the questionnaires.

5. EMPIRICAL INVESTIGATION OF THE MODE OF TEACHING IN THE ALTERNATIVE SEMESTER

5.1. The mode of teaching in the alternative semester

The specific mode of teaching (teaching and learning approach) comprised of formal lectures and tutorial classes focusing on dynamic student participation and compulsory attendance is required (at least 80%). Throughout the lectures students are firstly given the opportunity to attempt mathematical problems individually and/or in groups before the solutions are explained and discussed. At the end of each lecture all students write a lecture test (marked by the lecturer) to provide significant information about the students' understanding of particular concepts. To reinforce knowledge and skills, these tests are again repeated at the beginning of the following lecture. During tutorial classes students are actively involved by working on assignments, which are open book exercises. The lecturer and a tutor are available for one-on-one interaction, support and clarification of concepts. Solutions to assignments are posted on UJ electronic learning environment (uLink). All class activities (lecture tests and assignments) count towards the official semester mark.

5.2. Quantitative research findings

In the first semester of 2014, 665 students enrolled for MAT1A01 of whom 334 passed the module, a throughput rate of 50%. In the second semester of 2014, 163 students enrolled for ASMA1A1 of whom 120 were students who failed MAT1A01. At the end of the second semester of 2014, 112 students passed ASMA1A1 of whom 89 were students who failed MAT1A01 in the first semester of 2014. These figures indicate that a total of 63,6% of the students who originally enrolled for MAT1A01 in the first semester of 2014 passed the course, an increase of 89 students. The table below displays the quantitative research findings.

Table 3. Main stream and alternative semester course (sample group) findings

Module	MAT1A01		ASMA1A1	
	Main Stream MAT1A01 1 st semester 2014		Alternative semester ASMA1A1 2 nd semester 2014	
Calculus of one variable functions	Number of students enrolled	665	Number of students enrolled	163 (120 from *)
	Number of students passed	334	Number of students passed	112 (89 from *)
	Number of students failed	331*		

5.3. Qualitative research findings

In the ninth week of contact sessions during the first semester of 2015, individual student feedback on their live course experiences was collected via a semi-structured open-ended questionnaire. Main categories of feedback, incorporating directly quoted student views, are summarised in the following sub-sections.

Student experience of the mode of teaching (in class activities)

Student feedback reported on challenges as well as opportunities generated by the specific in-class activities. Challenges are categorised in three main groups; *nature of content* (challenging), *time on task* and *disruptions* (group work sessions). Opportunities are categorised in two groups; *individual attention* and *class administration*. An overwhelming positive reaction was reported by most students on the one-on-one contact between lecturer and student, compulsory class attendance and lecture tests –

- “Staying focused and concentrating”.
- “Understanding the activities immediately”.
- “A student gets to ask any question without the mentality of wasting other students’ time or without feeling embarrassed”.
- “Part of the reason I failed MAT1A01 was absenteeism from class”.

Mathematical proficiency and self-directed learning skills

Noticeable dividends from student feedback are perhaps the positive influence of in-class activities and measures on students’ self-regulated learning skills together with the improvement in mathematical knowledge and skill. Almost all students reported positively that their mathematical proficiency (knowledge and skills) improved by the mode of teaching. They are more motivated and prepared to study unknown mathematical content, although some students indicated they would still require some support and are scared of failure –

- “I now learn the lesson properly and practice after class”.
- “ASMA encourages more practice through the class tests”.
- “Shows just how out the box I am able to think”.
- “I do not want to fail this module again.”

The most valuable conclusion drawn from the student feedback was the improvement in their own actions in taking their education seriously, planning their time and being disciplined.

6. IN CONCLUSION

The purpose of the study was to investigate the influence of an alternative semester programme on the mathematical proficiency of a group of first year students and to reflect on the development of the students’ self-regulated learning skills by means of the mode of teaching. Through this teaching and learning strategy, which incorporated carefully planned in-class activities, students were encouraged to more regularly engage with the mathematical content. Besides the expectation of frequent practice, by the integration of lecture tests, assignments and one-to-one contact time the lecturer could monitor student improvement on a regular basis. As students experienced growth in their mathematical ability, their confidence and motivation increased. Although some students indicated the mode of teaching was challenging, it is delighting to experience how students take responsibility of their studies and future.

The positive increase in throughput numbers, confirmed by the quantitative data, provided evidence for the continuation of the alternative semester programmes at the University of Johannesburg.



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