



INTERVENTION BY MEANS OF A MATHEMATICS LEARNING CENTRE IN THE DEPARTMENT OF MATHEMATICS AT THE UNIVERSITY OF JOHANNESBURG

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ABSTRACT—Mathematics students at schools in South Africa are faced with an inadequate mathematics syllabus, a tremendous shortage of qualified teachers, and unreliable matric results as an indicator of ability. To cope with the transition from matric to university level mathematics, particularly in the sciences, students are ill-equipped to bridge the gap. These students require rigorous support, motivation and skills. The first aim of the paper is to identify the various interventions which take place in the Mathematics Learning Centre - which caters for first, second, and third year mathematics students. The second aim is to investigate the effect of these interventions on student performance and subsequent throughput rates. The final aim of this research paper is to formulate a set of guidelines which will hopefully bring about a significant contribution to effective teaching and learning of mathematics at a tertiary level. These interventions, if planned and implemented efficiently, should assist students who feel overwhelmed, and help them to become more positive and independent so that they can acquire the skills needed to cope with tertiary-level mathematics.

Keywords: Intervention; Tutor; Peer Education; Mathematics

1. INTRODUCTION

The need for intervention in the sciences on a tutoring level has increased in South Africa over the past twenty years, as a result of the various adjustments to the South African school syllabus. In general over the past twenty-five years, there has been a growing need for a tutoring approach to aid learning (Falchikov, 2001; MacDonald, 2000). Student data can inform lecturers at an early stage that intervention is necessary, thereby notifying students and referring them for help (Hrabowski et al., 2011). In our experience, the earlier we can intervene with at-risk students the better. We identify at-risk students in the first few weeks of lectures based on their performance in weekly class tests and, at a later stage, based on their semester tests. Students that are failing the course (below 50%) for class and semester tests are considered at risk. In fact, we include those students who are getting between 50% and 55% as well. We are then able to single out these students and encourage their participation in the intervention strategies discussed below.

Damon and Phelps (1989) identified three different forms of peer education: peer tutoring, cooperative learning, and peer collaboration. Cooperative learning takes place when learners work together in a team, combining their resources on a particular topic; and peer collaboration takes place when learners work together, simultaneously, to approach general aspects of a topic. These latter two forms, in the context of learning mathematics at university level, have been discussed by D'Souza and Wood (2003). The former form (peer tutoring), which is the focus of this paper, takes place when one learner assumes the role of a teacher, and other learners assume the role of the students. Peer tutoring is different from the other two forms of peer education since the learners in this form are not on an equal footing in terms of roles.

1.1 The many facets of peer tutoring

Topping and Ehly (1998) defined peer learning as "the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions, where both tutees and tutors benefit from the transaction". Topping and Ehly (2001) identified at least thirteen "organizational dimensions" to peer tutoring, briefly discussed here and which we will refer to frequently in what follows:

- (1) Curriculum content: the knowledge or skills under consideration.
- (2) Contact constellation: the number of tutors and the number of tutees. For example, the tutors and tutees might be paired or there might be one tutor and multiple tutees.
- (3) Within or between institutions: the institutions involved. For example, these might be university students assisting high school students.
- (4) Year of study: the year of study, and ages of the tutors and tutees.
- (5) Ability: the tutors and tutees may be similarly or differently skilled.
- (6) Role continuity: learners may assume both the tutor and tutee roles
- (7) Time: the peer tutoring process may occur inside or outside of class time
- (8) Place: necessarily the peer tutoring may occur in several locations, including inside the classroom, or at a separate facility
- (9) Helper characteristics: the qualities that the tutors possess. For example, are the tutors gifted students?
- (10) Characteristics of the helped: the qualities that the tutees possess. For example, are the tutees 'average' students?
- (11) Objectives: the goal may be to improve academic performance, or even self-image.
- (12) Voluntary or compulsory: is the peer tutoring forced or more natural?
- (13) Reinforcement: perhaps the tutors receive payment or the tutees receive a certificate?

Among the organizational dimensions, there are two broad sub-categories of peer tutoring, namely reciprocal and non-reciprocal peer tutoring:

Peer tutoring is described as 'reciprocal' when the learners are on the same academic level, as opposed to more senior learners tutoring less senior learners. Reciprocal peer tutoring is just one organizational branch of peer tutoring and is closely related to cooperative learning, since in most applications the roles of both student and teacher are adopted by all students at some point during the process. Reciprocal peer tutoring was largely pioneered by Fantuzzo and his associates in an attempt to capitalize on the skills and experience gained by students, in their preparation to tutor other students (Pigott, Fantuzzo, & Clement, 1986; Wolfe, Fantuzzo, & Wolfe, 1986).

The intervention strategies discussed in this paper are non-reciprocal, since in our context, the situation is predominantly that of senior students tutoring students that are their juniors. Although the senior students further develop their understanding of the content tutored, and hone their communication skills, the objective of the peer tutoring is the academic improvement of the tutees. Some studies considering the effectiveness of non-reciprocal peer tutoring, include the following: Carroll (1996) considered the use of senior medical students to assist with the tutoring of first year biology students; Bush (1985) investigated senior accounting students tutoring first year accounting students. In both situations the senior students received payment for their services, but the peer tutoring practices were found to be extremely effective. Oats et al. (2005) trained second year mathematics students in how to learn and teach mathematics, and these students were subsequently paid to tutor first year students in their third year. The result was an overwhelming positive response to this initiative. Literature focusing on peer tutoring in mathematics at tertiary level is scarce, but recently Carmody and Wood (2009) considered this situation at the University of Technology in Sydney, Australia. In their paper, they discuss the extremely positive effects of peer tutoring, including the use of volunteers as tutors. They describe the situation as a "win-win" situation for all parties concerned.

1.2 Mathematics Learning Centre (MLC)

The Department of Mathematics at the University of Johannesburg has a Mathematics Learning Centre (MLC), based at the Department of Mathematics. The MLC is comprised of the services of the Tutor Support Centre (TSC) and Saturday Revision Classes (SRC). Applicant tutors must receive a minimum of 60% on average for the mathematics courses they have completed. We find that very often the 'non-A' student makes for a better tutor, since he has had to struggle a bit and therefore has the empathy necessary when dealing with struggling students. As far as possible, honours and masters students are used, but the tutors are predominantly made up of second and third year tutors assisting tutees with the levels that have been completed by the tutors. Tutors are selected for their teaching ability, as well as their mathematics ability. As part of the selection process, they are required to present a lecture. Great emphasis is placed on how they come across verbally, as well as professionally. These tutors are chosen for their ability to work independently. They are focused and reliable and are considered good role models to the students they tutor.

1.2.1 Tutor Support Centre (TSC)

The Tutor Support Centre operates daily from 09:00 to 16:00. Tutors are available to assist struggling students. Each time a student sees a tutor, they fill in a logbook. In this way it is easy to see who has made use of the assistance provided (the tutee), who has provided the assistance (the tutor), and the extent to which the tutee is satisfied with the help that they have received.

With regard to the organizational dimensions (Topping & Ehly, 2001) discussed previously: the content is typically any content that the tutee has difficulty with, that the tutor has completed as part of his / her degree. Usually it is a pairing of one tutor with one tutee, but there are times when a couple of tutees (typically friends with a common problem area) receive help from one tutor. The tutor is usually at least one year more senior than the tutee, and a sufficiently strong student to be able to assist the tutee. The roles of student and teacher do not change, and the primary objective is the improvement in academic performance of the tutee. The tutor is paid for his / her services.

Students are notified about the centre via Mathematics staff in lectures, and U-Link (our internal student website). Students are encouraged on a daily basis to make use of the TSC to acquire support with content dealt with during lectures. After students have attempted the various recommended exercises from the textbook, they are able to have a tutor check their attempts. In this way they have access to continual support. Problem areas can easily be identified and consolidated.

The tutors become an indispensable support system, particularly in preparing students for their semester tests and examinations. One on one assistance is readily available.

1.2.2 Saturday Revision Classes (SRC)

A tutor, employed by the MLC, covers the syllabus already covered in the preceding lectures during Saturday Revision Classes. This tutor is selected for these crucial support classes based on their outstanding teaching ability and deep understanding of the syllabus. Tutees have the opportunity to ask questions and to attempt mathematics problems themselves. They are able to address their own personal difficulties with any of these mathematical processes, thus preparing them for the semester tests, and ultimately the exam.

With regard to the organizational dimensions (Topping & Ehly, 2001) discussed previously: the content is restricted to the content of that specific module. One tutor typically assists multiple students in a group (often more than a hundred students). The tutor is at least one year more senior than the tutee, and a sufficiently strong student to be able to assist and manage the fairly large

group of students. The roles of student and teacher do not change, and the primary objective is the improvement in academic performance of the students. The tutor is paid for his / her services.

These Saturday Revision Classes continue throughout the year, including just before the final exam; and the classes run from 09:00 to 15:00. Emphasis is on understanding of the concepts, as well as extensive implementation of these concepts. The sessions are designed so as to improve depth of understanding, as well as enhance mathematical procedures. On average they run 2/3 of the semester

A class register is kept for record purposes.

2. MEASURING THE EFFECTIVENESS: STUDENT PERCEPTION

In an attempt to gauge the effectiveness of the interventions offered by the MLC, it would be ill-advised to make statistical inferences based on student marks, since the students cover different sections of work for each assessment. Furthermore, many of the students that make use of the intervention strategies do so *after* they perform poorly in an assessment; and the improvement, if any, forms part of many different sections in the examination so it is difficult to pinpoint the benefit of the strategies. Although a survey is not the most reliable statistical source, no quantitatively superior source was available to us. Hence, in an attempt to establish the worth of these interventions we looked to the viewpoints of the students themselves. We conducted a survey in two representative classes of the first-year 'extended' students (these students cover the first-year mathematics syllabus over 18 months, since they typically have poorer matric results than their 'mainstream' counterparts). There were 154 students that participated in the survey, and the results are shown below:

2.1 Tutor Support Centre (TSC)

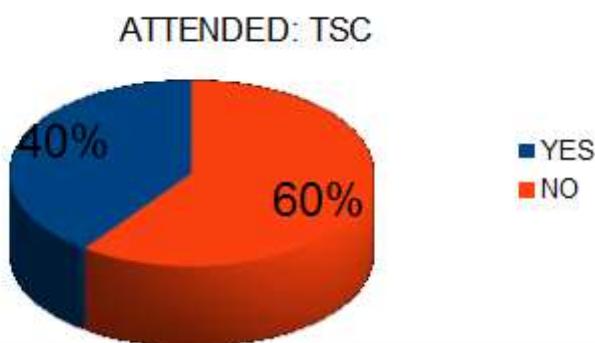


Figure 1: Attendance of the Tutor Support Centre

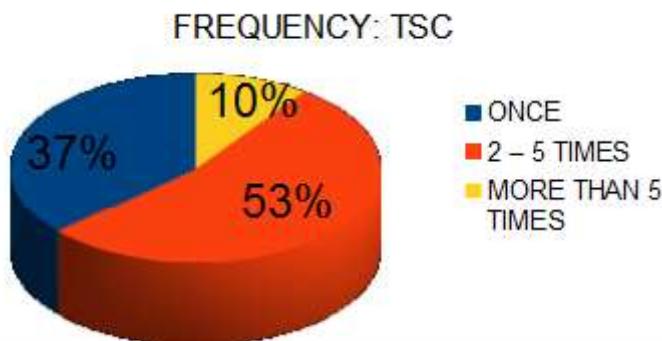


Figure 2: Frequency of attendance of the Tutor Support Centre

EXTENT OF HELP: TSC

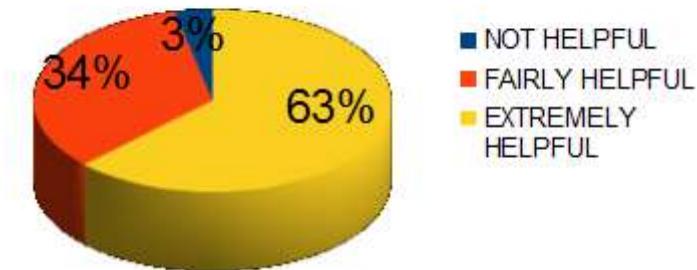


Figure 3: Extent to which the Tutor Support Centre assisted students

Summary: the majority (60%) of students surveyed did not make use of the one-on-one tutoring offered by the Tutor Support Centre at the MLC. Many of these students admitted to just not making enough of an effort to go for tutoring. However, 63% of those that made use of the TSC did so more than once, which suggests that students who went to the TSC had a positive experience toward this intervention. This is confirmed by the 34% of students that attended the TSC who felt that the tutorship services helped them and the majority (63% who found the tutorship services extremely helpful.

2.2 Saturday Revision Classes

ATTENDED: SRC

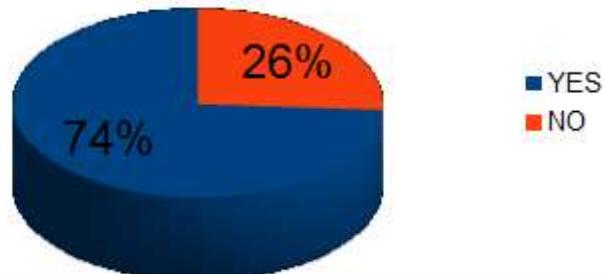


Figure 4: Attendance of the Saturday Revision Classes

FREQUENCY: SRC

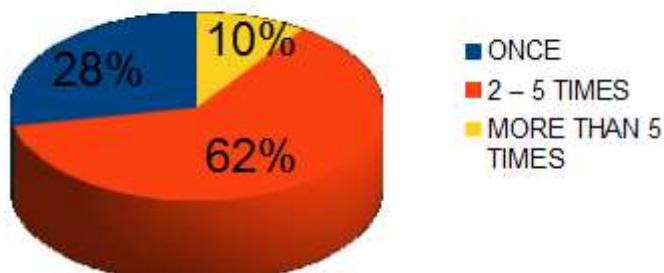


Figure 5: Frequency of attendance of Saturday Revision Classes

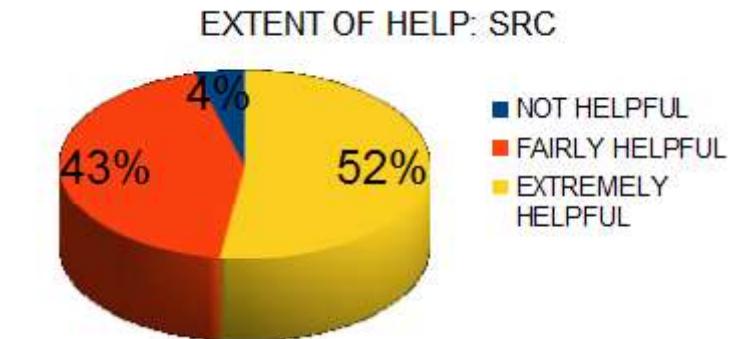


Figure 6: Extent to which the Saturday Revision Classes assisted students

Summary: in contrast to the TSC, the majority (74%) of students surveyed made use of the Saturday Revision Classes. Similarly to the TSC, the majority (72%) of those that made use of the SRC did so more than once, which again suggests that students who went to the SRC had a positive experience toward this intervention. This is confirmed by the 43% of students that attended the SRC who felt that the classes helped them, and a further 52% who found the classes extremely helpful.

2.3 Perceived Worth of Interventions

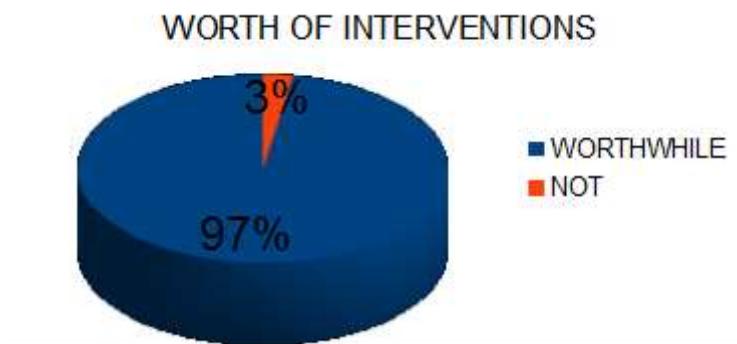


Figure 7: Worth of the Mathematics Learning Centre and the Saturday Revision Classes to students

Summary: we can see from the graph above that there is an overwhelmingly positive perception, among the students surveyed, toward the interventions of the Mathematics Learning Centre. Roughly 97% of students felt that these interventions were worthwhile and should continue.

2.4 Comparative Level of Support

LEVEL OF SUPPORT: UJ VS SCHOOL

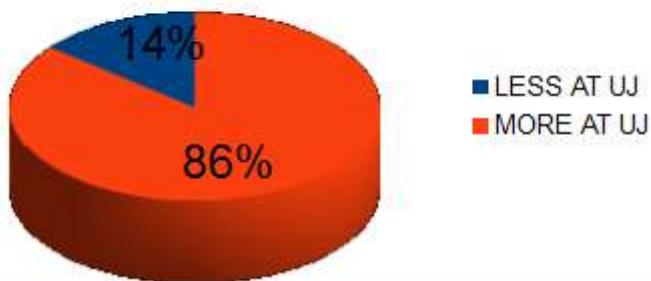


Figure 8: Level of support offered in mathematics at UJ as opposed to school

Summary: it is clear that most (86%) of the students that participated in the survey felt that there was more support offered in mathematics at UJ than the support that they received for mathematics at school. In their motivations, many of the students who felt that they had received more support at school, attended private schools where classes were smaller and so individual attention during classes was possible.

3. LESSONS LEARNT: INTERVENTION OUTCOMES

It appears as though both the aforementioned interventions have been met with an overwhelmingly positive response from students. Most of the students who made use of one or both of these interventions, continued to do so, and the vast majority of these students felt that they had benefited from the interventions. Two of the outcomes of this investigation are the following:

- Students appear to prefer the group revision class setting as opposed to one-on-one tutoring. Possible reasons for this may include:
 - (a) students often don't have clearly defined, specific questions that they want to ask - they first need to get to grips with a broader understanding of the work before they can approach the specifics;
 - (b) students may feel more comfortable in a group setting rather than in an individual setting, where their personal weaknesses are more apparent;
- If we can encourage more students to attend such interventions, the data suggests that they will return for more assistance (most students that attended at least once, attended more than once).

students possibly lack the self-confidence to walk into a room of tutors and students and address a tutor to ask for assistance. Perhaps it could be investigated whether students could be given a deadline to sign in at the MLC by a certain date each semester , thereby 'breaking the ice' so that they feel more comfortable seeking assistance at a later stage. If students could be encouraged to actively participate during lectures, to ask the questions they need answered in the moment and not feel intimidated by the presenter of the lecture, then many students would leave a lecture with a better understanding than they normally would.

Furthermore, the general feedback from students in the classroom is that they appreciate the lecture support, tutor support and teaching compared to their school experience. There seems to be a noticeable appreciation for the quality of teaching. They also appreciate the emphasis that is placed on assessment. Assessing students is labour intensive, but proves to be crucial in the learning process. It is a way of forcing students to master the various sections. It provides a sense of urgency to acquire the necessary skills in minimum time.

We suggest that both group revision classes and tutoring services should be used as interventions to assist in mathematics education. The group environment greatly helps students to develop their broad-based mathematical skills; and the individual tutoring environment allows students the individual attention that so many of our students require. In this way they are able to address their own individual problem areas. It may be worthwhile to make attendance of at least one of each such intervention, compulsory - to encourage students to see the benefit thereof, in the hopes that they will return regularly to get the assistance that they need. Forcing them to become more comfortable approaching peers or tutors or lecturers would surely help them gain the confidence to seek help voluntarily, thereby taking responsibility for their own learning, and thereby aiding the entire teaching and learning process.

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