

# From desperation with mathematics results to liberation through action research

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## Abstract

*One of the most serious challenges that face educators at tertiary institutions is how to facilitate learning for students impaired by a variety of social and academic barriers. These barriers may vary, for example, from the language of learning and teaching, which might be a second or third language of the student, to poor pre-knowledge and lack of efficient study skills. A solution to the problem presented by these barriers may be sought through classroom-focussed research, and more specifically by using action research as a method. Action research seems to be most suitable approach for investigating the problem addressed in this study, as it seeks to suggest plans and processes aimed towards the solution of a problem. The solution of the problem also needs to be seen within the Outcomes Based Education (OBE) framework, which has necessitated a change in the way education in tertiary institutions has to be conceptualised. For example, the use of group work has become very important, as is the need to revise existing assessment strategies.*

*This paper reports on a research project undertaken in the Faculty of Engineering at the Technikon Northern Gauteng (TNG) with first-year mathematics students. These students were enrolled in the departments of Civil and Electrical Engineering respectively. The aim of the project was to investigate the impact of tutorials on the performance of the students in introductory mathematics. Generally, these students come from disadvantaged backgrounds, and they are often under-prepared for studying at tertiary level, resulting in poor performance in introductory mathematics. As a way of dealing with their under-preparedness, students received tutorial support, which engaged them in group activities, gave them the opportunity to practise (mathematics), and also exposed them to an alternative assessment strategy in the form of portfolios. Questionnaires, focus group interviews and observations were mainly used to elicit data from the students. The questionnaires were also viewed as having a diagnostic purpose that would result in some remedial intervention being put in place. The preliminary findings of the study indicate that, under certain circumstances, tutorials could improve the performance of students in introductory mathematics.*

## **Introduction and background**

Technikon Northern Gauteng (TNG) is a historically disadvantaged institution and the majority of the students are from historically disadvantaged backgrounds. One of the consequences of this sustained disadvantage is that students are often under-prepared for tertiary education. Most of the students in introductory mathematics (MTHS1) could be described as “at risk”

*The term “at risk” is used as an euphemism for students who were exposed to a wide range of educational factors, including the manifestation of unacceptable social behaviour, the inability to keep up with the pace of instruction, the failure to respond positively to the instruction offered in basic academic skills, and a limited repertoire of experiences that provide background for formal education (Howard & Anderson, 1978: 221-231).*

The failure rate of students in MTHS1 has been a concern at TNG for some time, but during semester one of 1999 it reached an all-time low. The sub-minimum mark for admission to examinations is 40%. Based on this, 35,45% of the students were not admitted to the examinations. The pass rates after this examination was 32,73%. An action research project (AR), funded by AusAID as part of an Australia - South Africa Institutional Links programme was conducted in order to determine the reasons for under-achievement as well as to introduce remedial actions. The outcome of this project was a list of possible reasons for the inadequate progress of students, as well as the introduction of tutorial classes (Louw, 2003: 214-216). Additional opportunity to practise was identified as a possible remedial action.

Parsons and Meyer (1990: 325) caution that failure at tertiary level is not simply a consequence of inadequate intellectual capabilities combined with insufficient effort by the student, when referring to previous attempts and approaches by educators to improve student performance. The set members (staff members involved with the project) realised this, but also agreed that something had to be done to assist the particular students we serve.

## **Statement of the problem**

All aspects relating to teaching and learning of mathematics, problem-solving skills, self-image, critical thinking and practising of mathematical skills were looked at by means of a few research questions.

## **Research questions**

The study aimed at investigating the following research questions:

- What is the impact of tutorials in mathematics on problem solving skills and critical thinking?
- What is the impact of tutorials on the self-image of students, with reference to mathematics and achievement in mathematics?
- What is the impact of tutorials on achievement in mathematics?
- What is the role of tutors with respect to creating positive role models?
- Is there a need for students to communicate mathematically in their mother tongues?

- How successfully can portfolio assessment be implemented?

### **Aims of the research**

Experience at TNG (Steyn, 2002) showed that students do not complete their homework in mathematics on a regular basis. This lack of practise impacts negatively on their performance. Mathematics is a subject that needs daily practise (Maree, 1997: 14). The study aimed at:

- creating structured small group interaction to enable students to practise mathematics problem solving skills and critical thinking;
- enhancing the students' self image through the small group activity;
- establishing positive role models through the tutors;
- facilitating small groups where students can communicate in their mother tongue; and
- introducing portfolio assessment as a complimentary way to assess performance in mathematics.

### **Method: Action Research (AR)**

Cohen and Manion (1980: 178) define AR as:

*essentially an on-the-spot procedure designed to deal with a concrete problem located in an immediate situation. This means that the step-by-step process is constantly monitored over varying periods of time and by a variety of mechanisms (questionnaires, diaries, interviews and case studies, for example) so that the ensuing feedback may be translated into modifications, adjustments, directional changes, re-definitions, as necessary, so as to bring about lasting benefit to the ongoing process itself.*

The set members could identify with the above-mentioned definition of AR and modified and adjusted the project to ensure lasting benefit. One such a decision was to launch a new project with an experimental design to investigate whether the tutorials are really the cause for improved performance in MTHS1. The nature of educational research often prohibits the researcher from using a pure experimental design. Researchers make use of a quasi-experimental design, as was the case in this study.

There are a number of versions of action research. Zuber-Skerritt (1991: xv) proposed that action research is based on the assumption that people can learn and create knowledge:

- on the basis of their concrete experience;
- through observing and reflecting on that experience;
- by formulating abstract concepts and generalisations; and
- by testing the implications of these concepts in new situations, which will lead to new concrete experience and hence, the beginning of a new cycle.

## **Procedure**

The aim of this AR project was to accommodate certain randomly selected students from Electrical and Civil Engineering in tutorial classes in order to solve mathematical problems and to practise mathematical skills in a small group setting through the help of a tutor. The tutorial (experimental) groups had to total an amount of 24 students in each of the diplomas. These 24 students were divided in two groups of 12 each since it was felt that 12 is the optimal number of students for such a group, bearing in mind that structured observations had to be done.

Tutors were assigned to tutorial groups and met once a week to conduct the tutorial session. The tutors also met once a week with the author to receive and share information.

Structured observations were made during the tutorial sessions. Tutors and lecturers kept reflection diaries and student portfolios provided artifacts to contribute towards the observations made. The author and one trained student assistant did the structured observations weekly by using an observation sheet that included *inter alia* the following observations:

The scheduled time of the session;	each student's time of arrival;
The actual time the session starts	the amount of homework done by each if his/her portfolio was there;
Level of participation;	Whether they use their mother tongue;
Whether they volunteer to solve problems	Whether they take initiative in the group;
Whether they are the leader in their group;	Whether they act destructively e.g. cell phone;
Whether they ask questions.	

One of the interesting facts that emerged from these observations was that students do not often speak in their mother tongue, despite the fact that language problems are often offered as an excuse for their poor performance. When they were asked about this phenomenon during the focus group interviews, a very logical explanation came to the fore. They feel comfortable and safe in the small group and would rather use the opportunity to practise their English.

The author and the tutors met weekly in order to reflect and address potential problems. During these meetings experiences from all four groups were shared and the observers could also share their opinions with the tutors. The groups were similar, yet unique. The tutor's personal styles dictated the atmosphere in the group to some extent. However, the fact that students were used as tutors posed a certain problem. Students often get caught in their own academic spiral and then their tutorial duties took a back seat. Non-attendance occurred once or twice and the author then stood in for that tutor. Observation during such a session was impossible. All of these issues were reflected on weekly and efforts were made to avoid repetition of such situations.

## **Sampling**

The tutorial groups were selected through stratified random sampling, with gender and grade 12 (final school year) marks in mathematics, science and English as strata. This sampling method ensured that students with inadequate performance as well as excellent performers formed part of the tutorial groups. The 3 strata in their matric marks were calculated by taking the average marks for English, mathematics and science as follows:

strata1	strata 2	strata 3
below 40%	40 - 60%	above 60%.

The female students were proportionally randomly selected.

The remaining students formed the control group. For the sake of fairness and bearing ethical issues in mind the students in the control group did not receive zero intervention. They had a venue booked for them and a tutor who was especially trained to only facilitate their questions and not to initiate any form of problem solving on his/her part. The students could address any problem to the tutor, and he/she would guide them in the solving of the problem. The tutor had to give as little input as possible.

## **Measuring instruments**

The study orientation questionnaire in mathematics (SOM) (Maree 1997) was used as a pre- and posttest. This standardized questionnaire describes six fields associated with the study of mathematics, i.e. study attitude (SA), mathematics anxiety (MA), study habits (SH), problem-solving behaviour (PSB), study milieu (SM) and information processing (IP) (Maree, Prinsloo & Claassen 1997). This questionnaire was conducted at the beginning and end of the semester.

Structured questionnaires were designed to monitor students' perceptions and progress after every semester test. This was supplemented by focus group interviews.

The questionnaire enquired, among other things, whether the student performed according to his/her expectations. If the answer was YES, they had to choose the reasons for their success from a list of possible answers. The same applied to the answer NO. It was obvious from the answers that many students operate with an external locus of control, since the reasons chosen were usually very neutral and not personal at all.

**Table1: Responses for the four questionnaires on the outcomes versus the expectation**

QUESTION	RESPONSE	NUMBER OF STUDENTS			
Did you perform according to what you have expected in the previous test?		Civil quest 1 N=23	Electric quest 1 n=23	Civil quest 2 n=18	Electric quest 2 n=18
	Yes	1	3	12	11
	No	22	20	6	7

A possible explanation for the very negative response in test one versus a more positive response in test two is that many students were not used to the fast pace of tertiary education yet by the time the first test was written. The reason for the smaller number of questionnaires completed for the second time, is non-attendance by students. The students were informed that they would get their tests back on that day, and that the memorandum would be discussed.

These questionnaires were followed up by focus group interviews that served to triangulate the data. Students confirmed the trends that were picked up in the questionnaires. They were led to understand that they are the architects of their own progress.

## **Limitations**

The sample size was relatively small and the lack of enough female students further influenced the sample. Interpretations were made from a specific contextual framework and other researchers, working from another perspective might interpret the results in another way.

Generalization was not an aim of the study, since the investigation took place in the action research framework. One of the key aspects of action research is to investigate a specific group in a particular setting in order to improve the educational practice and to achieve better understanding about the situation (Kemmis & McTaggart, 1988: 5). This study adhered to this principle.

Another limitation was the human factor of educational research. Respondents are not only cognitively involved, but also emotionally. Their emotions often play a role in their response to questionnaires. Students in the experimental group shared their tutorial sheets with their friends in the control group and this could lead to the John Henry-effect (McMillan & Schumacher, 2001: 192), where respondents in the control group worked harder to compensate for the fact that they are not included in the experimental group.

## **Results**

### ***Quantitative***

The primary aim of the study was to determine whether tutorials in mathematics would impact positively on the mathematics achievement of students. Achievement refers to a student's final mark at the end of the semester. Students, who were refused examination entrance, would naturally be excluded from the model.

The SAS-programme (edition 8.2) was used for the statistical analysis. A student's final mark was used as the dependant variable and was modeled against the student's gr. 12-symbols, the SOM posttest and the student's position in the sample, i.e. experimental or control group. The p-values were calculated in each case to see to which extend the independent variable could explain the dependant variable.

After a process of stepwise selection was followed with the gr. 12-results against the final marks it became clear that grade 12-marks did not yield statistically significant p-values. The same procedure was followed with the SOM. The results for the SOM are shown in table 2.

**Table 2: p-values of the fields of the SOM (both cycles)**

<b>Model: Fields of SOM</b>	<b>Cycle 1: Experimental p-value</b>	<b>Cycle 1: Control p-value</b>	<b>Cycle 2: Experimental p-value</b>	<b>Cycle 2: Control p-value</b>
<b>Study attitude</b>	0.2394	0.0993*	0.9407	0.3337
<b>Mathematics anxiety</b>	0.1095	0.8684	0.6497	0.1563
<b>Study habits</b>	0.0364**	0.0489**	0.5298	0.3581
<b>Problem solving behaviour</b>	0.1472	0.1569	0.8796	0.0373**
<b>Study milieu</b>	0.6850	0.7893	0.4263	0.8393
<b>Information processing</b>	0.2117	0.5510	0.6130	0.1360
<b>Total for fields 1-5</b>	0.2426	0.0807*	0.7244	0.5597

\* Significant at 10% level

\*\* Significant at 5% level

The data showed a positive tendency but on the scatter plots it was clear that the SOM was not statistically significant as probability indicator.

The third model looked at the position of the respondent within the sample. The p-values are displayed in table 3.

**Table 3: p-values of respondents for tutorial versus non-tutorial**

<b>Model Diploma</b>	<b>Cycle 1 P-value</b>	<b>Cycle 2 P-value</b>
Civil	0.6809	0.8012
Electric	0.2515	0.8447

\* Significant at 10% level

Student achievement in both cycles showed insignificant p-values for Electrical and Civil Engineering students. Table 3 shows that students that got tutorials, did not achieved significantly better than their counterparts who were in the control group.

### **Qualitative**

Qualitative data was *inter alia* gathered through observations about presence of students in tutorials, as well as punctuality, effort by students and the use of mother tongue.

A structured questionnaire supplied data about the students' age, their performance in relation to their expectations and their perceptions on the advantages of the tutorials.

Focus group interviews yielded another rich source of data. The main questions for the focus group interviews were:

- ◆ Do you feel that tutorials are improving your mathematics performance?
- ◆ What about tutorials do you regard as positive?
- ◆ What are the qualities required by a student to be successful in tertiary mathematics?
- ◆ If you are not performing to your satisfaction, what do you do wrong?

After categorising of the data, the following categories and themes emerged:

Category 1:	Students' perceptions about the tutorials
Themes:	Tempo of work in the tutorial classes is slower. A support system was formed in the small groups. The use of mother tongue was seen as positive.
Category 2:	Study orientation
Themes:	Study habits and attitudes are not always optimum with students. Mathematics anxiety is present among a large number of students and they will have to learn to manage it. Some students have a less than favorable study milieu. Most students have ineffective time management and are reluctant to ask questions in class.
Category 3:	Personal opinions of students
Themes:	The tutorials increased their self-confidence. Some tutors acted as positive role models. The involvement of the lecturer was perceived as a positive factor in the study.

## Conclusion

The outcome of this study was enriching and liberating to the author, as she came to realize that it is not only enormous and expensive interventions that can lead to success. Sometimes the small gestures of goodwill and sincere interest and continued involvement can bear the same sweet fruits.

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