Cooperative learning at Port Elizabeth Technikon: Student attitudes and mathematics scores

S Potgieter* & P Webb
Port Elizabeth Technikon

Abstract

The pre technician course at the Port Elizabeth Technikon (PET) is an intervention programme designed to address the needs of under prepared and/or historically disadvantaged students seeking to pursue careers in science or engineering. This study investigates whether the mathematics test results of pre technician students who have been exposed to a cooperative learning strategy are any different to those of students who are exposed to standard strategies, and whether the strategy had any effect on the attitudes of the students participating in the intervention. First year electrical and civil engineering students formed the control group of 51 students, with whom traditional instructional methods were adopted. The pre technician group, consisting of 23 students, was exposed to the cooperative learning intervention for a period of three weeks. Statistical analyses of the pre test and post test data showed a statistically significant improvement in test results. Data generated by a questionnaire designed to ascertain the students’ attitudes and feelings in terms of the cooperative learning strategy indicate that students in the pre technician group also experienced non cognitive gains in terms of enhanced ability to operate in multiracial and multicultural group environments.

INTRODUCTION

Kagan (1992) severely cautions that unless we intervene in the plight of disadvantaged students we will face the inability to hold and educate the majority of our population to the minimum educational standards. Abrams and Jernigan (1984) add that it is the responsibility of higher education institutions to provide effective intervention strategies to help with the retention of under-prepared students.

The pre-technician programme, which represents such an intervention strategy, was introduced at the Port Elizabeth Technikon (PET) in July, 1989 to address the need for provision of access to historically disadvantaged and under-prepared students, and to provide them with essential tools necessary for success in their study careers (Sharwood 1998). Sharwood (1998:251) found that pre-technician students ‘lack a solid grounding in mathematics and science ... due to ... inadequate schooling’ characterised by ‘underqualified teachers and by the lack

*Contact person:
Sandra Potgieter, Department of Mathematics, Port Elizabeth Technikon, South Africa
E-mail: math0015@petech.ac.za
of laboratory facilities’ and notes that mathematics is a particularly high-risk subject in South Africa.

INSTRUCTIONAL APPROACHES AND CHANGES IN PARADIGM

As student populations throughout the world have increased in heterogeneity over the past decades, teachers have voiced concerns that traditional teaching methods and approaches are no longer adequate to provide access to learning for all learners (Lotan & Benton 1990). Varied language proficiency and academic heterogeneity, as well as diverse social and cultural backgrounds, mean that traditional modes of instruction, which usually encourage individual endeavour and competition, and which, in turn, can lead to feelings of isolation and discouragement, no longer suffice (Lotan & Benton 1990, Davidson 1990).

Sharan (1994) explains that the concept of a cooperative learning method does not imply uniformity in thought or procedures, yet authors and researchers working in different parts of the world show an extraordinary degree of concurrence. Coelho, Winer and Olsen (1989) describe cooperative learning as an approach to education and a repertoire of teaching strategies that are based on the philosophy that students can learn effectively in small groups. It comprises learning experiences in which students become responsible for each other’s learning and in which students attain effective group skills and learning strategies. Abrami, Chambers, Poulsen, De Simone, d’Appollonia and Howden (1995) advocate that cooperative learning is an instructional strategy based on positive interdependence coupled with individual accountability.

Whilst intimating that cooperative learning has the potential to enhance students’ learning, Abrami et al (1995) warn that it is neither a panacea nor certain to prove effectual in every classroom application. However, it does provide a contrast with traditional classroom practice by allowing students to work interdependently and not individually or competitively (Deutsch 1968). The degree of interdependence and accountability nurtured in the cooperative classroom is what distinguishes cooperative learning from group work, in which students sit together but are not required to contribute or participate equally (Coelho et al 1989). Aronson, Blaney, Stephan, Sikes and Snapp (1978), Shulman, Lotan and Whitcomb (1998) and Slavin (1980) all note that jigsawing may be an effective means of improving both academic scores and interracial and interethnic relations and, for this reason, jigsawing was chosen as the cooperative learning strategy used in this study.

COOPERATIVE LEARNING STUDIES IN SOUTH AFRICA

Internet searches (eg, SABINET ONLINE, OCLC and EBSCOhost) reveal that research linking success rates in mathematics with cooperative learning strategies is almost entirely restricted to American (USA) studies of secondary school
learners. Some of these studies are directed at disadvantaged Hispanic students but the South African situation, which is even more multicultural than that found in the Anglo-Hispanic communities of the United States of America, is quite different (Loucks-Horsley & Matsumoto 1999, Penlington & Stoker 1998). Also, the South African problem of providing increased access has only emerged in the new political dispensation, and therefore the body of existing knowledge in the field of this research is very restricted (Sharwood 1998).

The above, when married with Curriculum 2005’s emphasis on effective learner participation in group work (Pretorius 1998) and the problem of assisting under-prepared and disadvantaged learners, led to the framing of the following questions:

- Does the implementation of a cooperative learning strategy influence the mathematics test results of pre-technician students and;
- Does the cooperative learning strategy have an effect on the attitudes of students participating in the intervention?

**METHODODOLOGY**

This study is located within both quantitative and a qualitative paradigms. Firstly, an experimental, quantitative approach was used when attempting to answer the question whether the mathematics test results of students who have been exposed to the chosen cooperative learning strategy (jigsawing) were any different to those of students who are exposed to standard strategies.

A class of pre-technician students (n = 23) was used as the experimental group, while two engineering classes made up the control group (n = 51), i.e. use was made of non-probability sampling. In other words, whatever subjects were available were used, a technique otherwise known as convenience sampling (McMillan & Schumacher 1993). The natural limitation of this means of sampling is that generalisation is restricted because the sample is not representative of a larger population (McMillan & Schumacher 1993). Optimally, the control and experimental groups should be carefully matched to strengthen the design and optimise validity.

A more qualitative approach, which included a closed form, Likert-type questionnaire to gauge attitudes toward the intervention, was administered to the experimental group after the cooperative learning intervention had taken place. Items on the questionnaire were scaled in four categories ranging from ‘strongly agree’ to ‘strongly disagree’. No allowance was made for a neutral choice, thereby eliminating the tendency for respondents to cluster their responses in a middle category (McMillan & Schumacher 1993) as such behaviour may manifest itself when students are negative or bored and resist committing themselves to an opinion (Leedy 1997).
RESULTS
Initially, descriptive statistics were used to help explain and allow reflection on the composition and performances of the three groups. This was followed by a comparison of the electrical and civil engineering groups to ascertain whether there were any significant statistical differences between the two groups that would prevent their being merged to form a single control group. This was determined through the use of $t$-tests. It was decided that if no significant differences emerged, it would be useful to combine the two groups into a single control group, thereby strengthening the basis on which equalisation of the groups could be carried out (Leedy 1997).

Pre-test results were obtained by pooling the data generated by two tests administered to all three groups prior to the implementation of the jigsawing activities with the experimental group. As the intervention occurred between the second and third tests, the results of the third test were used as the post-test. The numerical information from Table 1 indicates the performances of the three groups and it was noted that although the pre-technician group had a lower mean score than the other groups on the pre-test, their post-test results were higher than the other groups. This was an encouraging initial statistic, and the significance of this difference was explored further by means of statistical analysis.

$\textit{t}$-TESTS
Variables that were considered when matching the control groups to optimise validity were age, grade 12 mathematics symbols, pre- and post-test results and gender (Leedy 1997). Analysis of the data generated (Table 2) yielded $p$-values that were all in excess of 0.05, thereby indicating that the groups were not significantly different from each other in terms of age, grade 12 performance, and pre- and post-test results. Gender, as a nominal variable, was tabulated in Table 3 where initial descriptive statistics already indicated that no seemingly significant differences in gender occurred in the control groups. This was confirmed by a $t$-test yielding the results indicated in Table 3.

On the basis of the evidence presented by the $t$-tests of no statistically significant difference between the two groups, it was decided to combine the electrical and civil engineering groups to form a single control group.

REGRESSION ANALYSIS
The regression lines which best fit the clustering of scores were given by $y = 19.2 + 0.49x$ for the control group and $y = 18.7 + 0.74x$ for the experimental group, where $y$ is the dependent variable representing the post-test, and $x$ the independent variable representing the pre-test. Positive gradients indicated a positive linear relationship between performance on the pre-test and the
post-test, signifying that students who did poorly on the pre-test also did poorly on the post-test and vice versa.

Further analysis using the post-test as dependent variable, and considering the variables which were controlled for in the ANOVA analysis, namely age, gender, grade 12 mathematics performance, pre-test results and membership of either the control or the experimental group, was then carried out. Raw coefficients \( (B) \) signifying the treatment effect and \( p \)-values indicating statistical significance were calculated to yield the results reported in Table 4.

Probability values greater than 0.05 for age, gender and grade 12 performance signify that none of these variables is statistically significant. A \( p \)-value of 0.00 (ie, \( p < 0.05 \)) for the ‘pre-test’ variable on the table indicates that there is a significant difference between the pre-test and the post-test. Similarly, a \( p \)-level of 0.00 for the ‘group’ variable denotes a significant difference in the results of the post-test between the control and the experimental groups. The magnitude of this difference is given by the raw coefficient \( B = 12.45 \), implying that the experimental group did 12 percentage points, on average, better than the control group for the controlled situation.

The correlation coefficient for both analyses was reported at \( R = 0.6 \). Considering that a score of 1.0 indicates a perfect linear correlation, it may be deduced that a moderate linear relationship exists between the results of the pre-test and the post-test (Gravetter & Wallnau 1998). The adjusted coefficient of determination, \( R^2 = 0.35 \), for the data in both analyses implied that approximately 35% of the variation in the post-test could be explained by the treatment.

ATTITUDES

Analysis of responses to questions in the questionnaire, which were formulated to elicit students’ attitudes towards the cooperative learning strategy and relations between the group members, clearly indicated that students in the experimental group enjoyed doing group work, with 82% of the students recording an ‘agree’ or ‘strongly agree’. Eighty-six percent of the respondents ‘disagreed’ or ‘strongly disagreed’ that group work was a waste of time.

Questions which probed the ease with which learners were able to approach their friends for help and the pleasure derived from aiding their friends, were responded to by 82% of the students ‘agreeing’ or ‘strongly agreeing’ that they could easily approach their peers and enjoyed helping them. Generally, there was a significantly positive correlation between students enjoying group work and relating comfortably with and willingly helping their peers.

Eighty-six percent of the respondents recorded that they had learnt a lot from their peers and 59% of the respondents felt that they had done more work in the group than they would have done on their own, suggesting that they felt increased motivation to perform. An encouraging 27% of the students ‘strongly agreed’ that group work had lead to successful learning, with 45% ‘agreeing’ with the
statement and only 18% ‘disagreeing’. Two students refrained from responding to
the question. Perhaps even more encouraging was the fact that 19 of the 22
respondents felt that they had become more responsible in the way in which they
approached mathematics, thereby suggesting a growth in maturity.

GROUP PARTICIPATION

An overwhelming 91% of students were happy with the contributions made by
their peers within the groups, with only two black, male students recording
frustration because the others did not work hard enough. It was interesting to note
that both of these students had performed well in their grade 12 mathematics exam,
suggesting that they were probably hard workers with high standards. They were
also two of the four students who recorded that they were not satisfied with group
members participating in a responsible way. However, this must be viewed against
the observation that 81% of the respondents were pleased with the ‘responsible’
contribution made by their peers.

Three students admitted that they had not worked hard because they believed
that others in the group would do the work. Interestingly, it was one of these
students who indicated earlier that he had not enjoyed group work, felt that he had
not learnt much from his peers and was frustrated that others in the group did not
work.

MISCELLANEOUS RESPONSES

Noise, as an external factor, was experienced as a distraction by five of the 22
respondents, but only one of the five felt strongly about its negative role. This
information could serve to inform following cycles of implementation of this
cooperative strategy.

DISCUSSION

The cooperative learning strategy adopted in this research study is endorsed by
Cohen and Manion (1997), Sharan (1994) and Slavin (1990) as being a sound
instructional approach for academically, ethnically and linguistically heteroge-
neous groups. The range of ethnicity in the experimental group provided an
opportunity to test how effectively jigsawing could help improve both academic
scores and interracial and interethnic relations (Aronson et al 1978, Shulman et al
1998, Slavin 1980). The data generated in this study suggests that not only did the
experimental group of students do better academically than the comparison group,
but that they became friends with one another and established camaraderie quicker
than they would have in a traditional environment, thereby supporting Davidson’s
(1990) contention that interpersonal relationships benefit from the implementation
of jigsawing.

The significant academic gains made by the Pre-Technician students appear to
support contentions by Davis, Maher and Noddings (1990) and Treagust, Duit and Fraser (1996) that knowledge is acquired through active construction rather than passive reception, and that this can be attained via cooperative learning strategies. The fact that in this study the strategy of jigsawing engaged both cognitive and affective behaviours in the learning process, supports Baird and White’s (1996) and Shulman et al’s (1998) notions that more enduring learning with understanding follow such holistic participation. However, testing of this presumption requires that the same students be tested at a later date to establish both recall and understanding, a notion that will be considered for a later implementation of this cooperative learning strategy intervention.

Confrey (1990) and Johnson (1998) argue that forcing students to become individually accountable for their own learning and for communicating this knowledge to their peers helps them towards enhanced understanding. However, the importance of retaining individual accountability for one’s own learning is also emphasised by Johnson and Johnson (1990), who maintain that an individual test should form part of the assessment profile of every student. The results of the individually administered mathematics test clearly indicated significant learning gains, and this may possibly be interpreted as an indication that students in the experimental group did assume individual accountability for their learning.

Certain limitations relating to this study were identified and may be considered during further implementations of the research. The use of interviews to clarify and substantiate responses recorded in the questionnaires would have added to the conclusivity of the findings and may have eliminated the possibility of subjective interpretations that jeopardise the accuracy of analysis and explanation. Furthermore, the use of a convenience sample in this study immediately places a limitation on the generalisability of the results as the question arises as to how representative these students are of all other first-year, disadvantaged South African students at tertiary institutions throughout the country. Further research at other institutions would confirm whether these results are applicable generally or whether, in fact, they are exclusively relevant to the PET students involved in this study. Further research at the PET could also indicate whether the results are generalisable to all Pre-Technician programmes or whether their relevance is restricted to the group under investigation.

Repeated cyclical implementations of the study should yield more conclusive findings and allow for longer periods of implementation. Although the three week strategy yielded significant findings, it is felt that longer periods of cooperative learning would enable students to become familiar with this teaching and learning approach and lead to even more positive social and academic outcomes. Furthermore, subsequent studies may be expanded to include the role of gender and its impact on the affective outcomes of cooperative learning.

Another possible limitation of this study relates to the use of the same lecturer for both the experimental and the control groups It is possible that even more significantly positive outcomes may have been achieved had a traditionally
oriented teacher been used for the control group and an innovative and engaging teacher who favours cooperative teaching for the experimental group.

Reading undertaken during the literature review of this study reveals that research into cooperative learning in the South African context, particularly at a tertiary level, is sorely lacking. Given the influx of under-prepared students to this level of education, it seems that prioritising the development of teaching innovations that enhance academic performance should receive greater attention than is currently the case. Furthermore, the work of Mkhabela (1994) demonstrates that significantly more attention should be given to the cultural dynamics that underpin the South African education scenario and that teaching strategies that are sensitive to culturally facilitating contexts should be explored and developed.

Shulman et al.'s (1998) conviction that implementation of a cooperative strategy is a demanding pedagogy was supported in this study as the teacher’s role proved to be demanding, a factor of the constant enthusiasm, pertinent questioning and challenging and incisive engagement required for successful implementation of the strategy. Nevertheless, the primary researcher in this study, who has been actively involved in teaching similar groups over a period of 12 years, noted that not only did students relate more positively to members of their own jigsaw group, but there was also a stronger sense of group cohesion amongst all class members.

REFERENCES


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