

Collaborative learning of mathematics by educationally disadvantaged students at a university

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ABSTRACT

This paper reports on a qualitative study of how collaborative learning as a pedagogic intervention was implemented in the Centre for Science Access (CSA) in a South African university. Students in the CSA are from educationally disadvantaged backgrounds. Collaborative learning was implemented to improve the mathematics knowledge and skills of these students. Collaborative learning involves organising students to work in pairs or in small groups to achieve shared goals or learning outcomes.

INTRODUCTION

In the past decade, South Africa has been undergoing a steady transformation relating to the need to widen access in the higher education sector. As a result there has been an increase in the number of educationally disadvantaged black men and women studying for science degrees. However these students enter higher education from diverse backgrounds and with different levels of social, educational, cultural and academic preparedness (Hartman & Warren, 1994). The knowledge and skills that these students bring with them on entry to university ultimately have an effect on their subsequent learning. Prior knowledge of a subject is essential for subsequent learning to occur and prior knowledge is a foundation on which new knowledge is built (Ausubel, Entwine, Gagne & Briggs, cited in Holtman & McKenzie, 1994: 276).

Researchers find that there has been a steady decline in the mathematics skills and knowledge among first year students in South Africa (du Preez, Steyn and Owen, 2008: 1). There is also a concern that students lack academic skills, including the lack of fundamental mathematical concepts and communication skills in mathematics. Similar observations were noted by researchers in the United States that first year students lack basic skills in mathematics and also lacked proficiency in English. Hence there is a need for remedial courses in mathematics and English (Graff & Leiffer, cited

in du Preezet al, 2008: 50).

In 2008, South African students were exposed to Outcomes Based Education (OBE); a new curriculum and teaching philosophy. It is not surprising that this cohort's progress in the higher education system has been subjected to scrutiny. The results in mathematics and physics were disappointing throughout the country. In 2009 a large number of students who wrote the new National Senior Certificate (NSC) registered at higher education institutions. Given the enrolment of the large number of underperforming students, strategies are required to increase student success (Wolmarans, Smit, Collier-Reed & Leather, 2009).

This paper reports on an intervention strategy implemented by the Centre for Science Access (CSA) at a South African university to improve the mathematics knowledge and skills of students. Students were required to work in pairs or groups comprising of four students in order to learn mathematics collaboratively. The major research question being:

How was collaborative learning experienced by the students?

COLLABORATIVE LEARNING APPROACHES

Smith & MacGregor (1992: 1) describe collaborative learning as

An umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together. Usually, students are working in groups of two or more, mutually searching for understanding, solutions, or meanings, or creating a product.

Collaborative learning activities vary widely, but most centre on students' exploration or application of the course material. Collaborative learning does not preclude students from also working independently. Students are given an opportunity to work independently of each other and to construct their own meaning so that they can make a contribution to the group discussion.

Collaborative learning attracts interest because it addresses several major concerns related to improving student learning. The essence of collaborative learning is that as students work together, they are actively involved and deepen their understanding of what is being studied. According to Barkley et al (2004: 4), collaborative learning is characterised by:

- active rather than passive learning
- equal contribution as members of the group
- a guide who facilitates rather than transmits information
- equal sharing by the facilitator and students in the teaching and learning experience
- acceptance of responsibility for learning by the individual student, as well as the group in which the student finds him/herself
- enhancement, through the articulation of ideas in a small group, of a student's ability to reflect on his or her assumptions and thought processes
- enhancement of student success and retention of learnt material
- acknowledgement of the value of diversity and of harnessing it in the learning process.

Further, Gokhale (1995) points out that collaborative learning promotes critical thinking and despite the advantages of collaborative learning there is little evidence of its implementation or of its effectiveness in higher education institutions.

ASSUMPTIONS ABOUT LEARNING

Collaborative learning takes on a variety of forms and is practised by teachers in various disciplines. It is linked to a number of important assumptions about learners and the learning process. These assumptions include: educationally disadvantaged students are diverse and are underprepared; students learning in groups; mathematics dialogue is an important component of collaborative learning; and the power of technology cannot be underestimated.

Educationally disadvantaged students are diverse and are underprepared.

In the South African context, educational disadvantage is due to the unequal distribution of resources, poor infrastructure and poor quality instruction. This may be attributed to the fact that a large number of teachers especially in mathematics and science are underqualified or unqualified (Phurutse, 2005).

Wenger (1998) argues that learning is not the mere acquisition of knowledge, i.e. only related to the cognitive aspect of learning. Learning, he maintains, is a process of social participation. Members are involved in relationships over time and communities of practice are developed around those things that matter to the people. Learning transforms who we are and what we can do; it is an experience of identity.

According to Webb, Nemer and Ing (2006) many current conceptions of learning, especially social- cognitive and social-constructivist perspectives, highlight the central importance of student participation in social interaction. In Vygotsky's (1978) view, for example, people learn concepts and strategies during interaction with others who are more knowledgeable and then internalise those concepts. Expressing and defending their beliefs and opinions and questioning others' ideas helps students to recognise, clarify, and repair inconsistencies in their own thinking. Using a group approach to learn mathematics is just another way of completing a task. The more heads working together, the sooner the task will be complete.

Students need to be actively involved in the learning process. They construct their own meaning and knowledge by connecting new information and concepts to what they already know, build hierarchies of understanding through the process of assimilation and accommodation. Mathematics is learned when students engage in their own invention and impose their own sense of investigation and structure. It is important for teachers to examine students' thinking about mathematics so that students engage in relevant tasks to build more valid perceptions of mathematics (National Council of Teachers of Mathematics, 1991).

Brodie (2007) points out that the new curriculum in South African schools required mathematics lessons be learner-centred. Learners should be encouraged to participate and contribute to the lesson. Learner talk is essential, because it allows the learners to express and clarify their own ideas. When the learners discuss ideas with

each other, the teacher is able to determine what the learners know and detect misconceptions.

Students learning in groups

Davis (1993) points out those students learn better when they are actively involved in the process and students who work especially in collaborative groups appear to be more satisfied with their classes. Other researchers (cited in Smith & Macgregor, 1992) report that students working in small groups tend to learn more of what is taught and retain it longer.

Peer teaching is a process whereby students teach their fellow students. Examples of peer teaching models are: Supplemental Instruction and Mathematics Workshops/Seminars. Mathematics Workshops are advocated by, among others, Triesman (cited in Smith & MacGregor, 1992) who was concerned about minority students in the University of California at Berkley. They experienced academic difficulty especially with traditional tutoring. Instead of remedial programmes, senior students are used to conduct mathematics workshops. These workshops are built around small group problem-solving where peer teaching is emphasised.

Mathematics dialogue is an important component of collaborative learning

In South Africa, there are eleven official languages and the language issue is a complex one. There is a continuing debate regarding which language should be used to teach mathematics in multilingual classrooms. Many teachers and students regard English as an international language and that English is important for higher education, jobs and hence a better life (Setati, 2008). English is a medium of instruction in almost all the universities in South Africa but is a second language for most students in the Centre for Science Access. The communication of mathematics ideas and concepts in the classroom may take place through various forms of language. We need to consider the place for language in mathematics classrooms. This may be spoken, written, formal or informal, between students and teacher or between student and student/s. In many 'real world' problem-solving situations an understanding of a

problem is developed by talking to others who have an interest in solutions. The symbolic approach is an integral part of teaching mathematics. However when teaching educationally disadvantaged students I adopt a developmental approach. It is recommended that teachers delay the use of symbols until proper meanings have been negotiated by the students (Pimm, cited in Simmons, 1993).

The power of technology cannot be underestimated

A number of institutions, worldwide and in South Africa are adapting their modes of delivery to include the use of integrated technologies. The need for technology literacy as well as the fact that some of our students are already experienced technology users must be taken into consideration (Broere, Geyser & Kruger, 2002).

RESEARCH DESIGN AND PEDAGOGICAL INTERVENTION

The Foundation Mathematics Module is a year-long module. The students are divided into five groups with an average of 36 students. For each of these groups, five lectures (45 minutes each) and a tutorial (2 hours and 30 minutes) were conducted per week. One of the groups, taught by the researcher, was the experimental group. The other four groups formed the control group, and were exposed to traditional methods of instruction.

The lectures and tutorials for the experimental group took into account the background of the foundation students, especially the type of schooling to which they were exposed. We first outlined the tutorial intervention. Students were required to come to each tutorial with their attempts for the relevant tutorial questions, which were given to them at the beginning of the semester. At the beginning of the semester students were put into three groups, and a demonstrator was assigned to each group. Each demonstrator was a senior third year student. For each tutorial the demonstrator first looked at the attempts of his/her students to the tutorial questions. This was done with the aim of assisting the students with their difficulties and to correct student misconceptions. Before the semester began, those demonstrators were trained on how to conduct the tutorials. Weekly meetings were then held with demonstrators to

obtain feedback about their students' prior knowledge, mathematical skills and progress. Feedback was received from the demonstrators during these meeting and also during each tutorial session. Those feedbacks were useful, informative, and influenced the pedagogical intervention. The lecturer then implemented remedial measures during the tutorial. To encourage active learning, students worked in pairs or small groups during the tutorials.

In class, for 20 minutes I taught, discussed concepts and did a few illustrative examples. Students were then divided into eight groups, consisting of four or five students, and worked on given questions. I then visited the different groups and assisted the students where necessary. After about 10 minutes some of the students wrote their solutions on the chalkboard. If students had any queries, other students helped to resolve them. I only intervened when there were misconceptions, and when disputes arose among the students.

Outside the class session, each of the eight groups researched one of the following topics in mathematics: Number patterns, Sets, Polygons, Pascal's triangle, Pythagoras, Trigonometry, Surface Areas, and Geometry. For each topic students had to read their notes and supplement their content knowledge.

Students were required to use the library and search the World Wide Web for information related to their topic. A double lecture was set aside to: [a] assist students to access information on the internet, and [b] to demonstrate and discuss exemplars so that students would know what was expected of them. Each group did a write-up of about four pages. The first stage of this required students to submit a draft after two weeks. These drafts were marked by the lecturers and demonstrators. Positive and constructive feedback was provided so that the students could improve their attempts.

Students made the necessary changes and improvements, and submitted the final version after a week. A member from each of the groups did an oral presentation of ten minutes in class, which was then followed by questions and queries from class members. These served a two-fold purpose: to determine how much the students learned from their research on the topic, and, it was of mutual benefit to the rest of the students. The written and oral presentations were assessed by the lecturer.

At the beginning of the second semester The Geometers sketch-pad (GSP), a software program, was installed for the CSA students. A double period (once-off booking) was used to teach the students how to use sketch-pad. Students were required to use the computers in the Local Area Network (LAN) and do exercises on curve sketching, by working in pairs. This offered the students the experience of working with many examples within a few minutes. They could see the results as they interacted with the software. It also afforded them the opportunity to practice the different types of graphs, which is an essential skill in mathematics.

Sketch-pad allowed students to sketch graphs, to get a greater understanding of graphs, and how to interpret graphs. They were also taught to solve equations graphically. The students then used this software program to complete some of the exercises (see Appendix A). Outside the normal lectures, the students worked in pairs to give them confidence and to support each other.

DATA ANALYSIS AND FINDINGS

Focus group interviews, the primary sources of data, were recorded and transcribed (see Appendix B). These interviews were then analysed to determine patterns and themes. Since I was the coordinator of the Foundation Mathematics module and I taught one of the classes, I saw myself as a data source. I observed the students in the class and in the LAN when they worked on collaborative learning tasks.

Interacting with peers

Students were asked to relate their experiences when they worked in groups. There was a strong notion of 'sharing' in the students' explanations of their collaborative learning experiences:

We come with different problems to solve together and all benefit.

Learning in groups makes things easy. Someone knows another method, a better method an easy method to solve equations yeah we share those things then collaborative learning is good.

The above excerpts indicate that students did not understand certain things in class and worked in their groups to find solutions. The individual's activities were with peers, interactive in nature and were of mutual benefit to all members in the group. With the assistance of more capable peers they were able to solve equations and improve their understanding of mathematics. Of greater significance was that they were able to find other (easier) methods of solving equations and their learning of mathematics was enhanced. This is also consistent with Vygotsky's (1978) view that learning takes place via mediation within a social context and students are able to solve problems in collaboration with more capable peers.

Collaborative learning also served to show some students the gaps in their understanding.

... I thought I knew everything, but when I joined in groups I saw the things that are missing. That is when I saw that group work was good.

Dlamin (not real name) was one of the few students who did mathematics on the higher grade in school and was confident of doing well in foundation mathematics. However while assisting other members in the group he realised that there were gaps in his knowledge. Another group leader, Hlengs pointed out that by teaching others, one's own understanding of mathematics improves.

One of the most important attributes of collaborative learning is the sharing of ideas and values. Students can specialise in knowledge and content and teach one another. Luvan had the following to say: 'Each one teach one'. I was surprised that this has multiple meanings. I knew the phrase from Laubach (cited in Ngaka, 2004), a

missionary, who used the strategy 'each one teach one' to fight communism and to win people over to Christianity. That strategy also had a strong undercurrent of self-improvement and modernisation. However, this approach is interpreted differently by the participants in this study. Students from particular provinces often come into higher education with a good understanding of one aspect of mathematics, e.g. students in Kwa-Zulu Natal (KZN) seem to be good in Trigonometry and they teach this to students who are not from the KZN province. Also, one student was able to see the potential of collaborative learning in studies in future.

Yes it will help in other faculties and careers next year. Start early and is a preparation for the future.

AN ARENA FOR ACTIVE LEARNING AND COMMUNICATION STRATEGIES

The one who knew, is the one who wrote. Those who don't know just watch and did not benefit.

...benefits, ...only to those members who participate in the group, And not to those who just listen. In mathematics must get down to work - everyone takes part and see the solution, then it can be good.

The development of social and team skills are a critical learning outcome. Many employers require employees to be eager to engage in teamwork. The students recognised that communication skills are important for active learning in groups:

If you don't know how to talk to a person, not in the group you can't tell the person that you are wrong. Being within the group shows that there are communication skills and listening skills.

It is often easier to decipher a useful strategy when communication goes awry in the course of learning collaboratively. Students recognised, for example, disruptive communication tactics:

... when some know the solutions and everybody wants to speak at the same time. We want to show others that we know...

If you make a noise and not focusing, end up spoiling everything...

There were students who did not participate and just watched, thus obstructing the communication processes in Collaborative Learning. Passive participation was not always a sign of laziness, however. It appeared to be linked, too, with scepticism on the part of some students as to the value of collaborative or cooperative learning for themselves as particularly individualistic students:

We came to varsity as individuals to work for yourself, I had a belief that I can do it by myself. Person like me who cannot study with another, I like to study on my own.

Such perceptions may have accounted for what appeared to be resistance from a few students to change from the previous experiences of learning. In most schools, teachers had taken the responsibility to do most of the work for the students. The emphasis was on procedures (recipes) and right answers. It is difficult to change the classroom culture that existed in most of the schools. Many researchers have pointed out that there would always be resistance from students who do not prefer working in groups and engage in active learning (Weimer, 2002; Felder & Brent, 2007) and indeed the above two excerpts are an indication that some students preferred to learn independently.

Language, of course, is closely tied up with communication skills. Bernstein et al (2007) point out that achievement in mathematics and science is very closely correlated to proficiency in the language of instruction. The language issue added to the diversity of the students in the experimental group. Most of the students in the CSA spoke isi-Zulu (140) while 44 spoke other languages. In the collaborative learning group 31 spoke isi-Zulu while five spoke other languages. In the November examination, set in English, less than 10% of the students solved the word problem. One student remarked:

English is a problem. Is a barrier if there are papers set in English?

Democracy appeared to dictate the choice of language used in the Collaborative Learning opportunities: Language was a problem but was ignored. Everyone was expected to speak the majority language in

the group.

However, when the understanding of difficult concepts was the students' priority, they discovered that it was

... better to mix English with the mother tongue. There are problems that need more explanations so need to translate...

I feel that some fail to explain things in English. It is better to explain things e.g. in Zulu than English, people can understand better.

There appears to be a difference in the language used by some teachers in mathematics and the language used by students especially those from educationally disadvantaged backgrounds. I have been involved in mathematics education for over 20 years and I always encourage the students to learn, speak and use the language of mathematics. Despite these efforts, some students have difficulty in understanding certain concepts in mathematics. However, it seems likely that it was just the different 'language' which accounted for the greater success the students appeared to have in helping their peers. One student had the following to say:

Some of the things that we did not understand in class, our classmates were able to help and discuss.

SOCIOLOGICAL DIMENSION

Learning is an experience of identity and can transform a person. Learning is not just an accumulation of skills and information, but a process of becoming a certain person or emulating a certain person. Conversely, we also would like to avoid to becoming a certain person (Wenger, 1998). Siya, one of the students was always quiet and reserved in class but wanted to 'understand the world of mathematics' so that he could be 'like one of those great masters ...'. In the first semester he was disorganised in his work and was struggling in mathematics. I had some doubts that he would pass the Foundation Mathematics programme. In the June examination he managed to get 40% and then proceeded into the second semester. Prior to the final examination he came regularly for consultation and he had to work very hard to obtain a pass. He

obtained 50% and was able to proceed into the first year of the BSc degree. I was pleasantly surprised that he scored 60% for mathematics.

According to Tinto (1997), meeting people and making friends for first year students is a major preoccupation of student life. The groups, which developed within the classroom, extended beyond it to provide further support to meet the challenges of academic life. Two students had the following to say:

As a diverse group there are different cultures. We like to learn about each other and interested in the type rituals. Make new friends, socialise and interested in that person... and ... help us prepare for the exam.

Students had the opportunity to work with other students from diverse backgrounds. They made new friends and learned about other cultures and rituals. Some students informed me that they studied in the library while others formed study groups in their residences. I also arranged for students demonstrators to be on standby so that they could assist these students especially when preparing for tests and examinations.

COLLABORATIVE LEARNING AS ONE OF A NUMBER OF LEARNING STRATEGIES (WAYS OF LEARNING INCLUDING TECHNOLOGICAL SUPPORT)

The learning categories are not mutually exclusive or superior or inferior to one another. Shroeder (1993) points out that students and lecturers have different views and styles of learning. Students should be able to choose the learning category that suits their individual style of learning. There was some evidence from the focus groups that students recognised different ways of learning:

Group work alone does not help a person. You also need time all by yourself to understand.

Students often pointed out that while working in groups they seem to understand the work being discussed. But when working alone they experience difficulty in recalling what was discussed. It is important that members in the group have a good understanding of concepts and procedures before engaging in self- study, especially when preparing for a test or examination. However this does not mean that group work should precede self-study. At times I find it useful to grapple with the problem or concept before listening to other members of the group. Hence I may be able to make a meaning contribution to the group and learn from the insights of others in the group.

As part of the collaborative learning task, students, working in pairs, were required to use computer programs to do research topics in mathematics. They were also required to use the Sketch-Pad(an electronic resource) to sketch graphs and solve equations graphically. Although the students did not comment specifically on the experience of working collaboratively with the computer program, I observed that they were engrossed in their tasks and were able to sketch graphs quickly and hence were able to save valuable time. Two students had the following to say:

There are some graphs, do not know where to start, it gives you an idea, where to start.

I found the Sketch-Pad was very useful and collaborative learning has helped me a lot. Sketch-Pad can be used for drawing straight lines. It can also be used for trig graphs and factorization.

STUDENTS' PERFORMANCE

From the findings, it is clear that the data indicates that a great deal of benefit was accrued by this methodology. While qualitative data cannot be measured in a mathematics test, the data provides information that is essential to measure graduate attributes and for success at a tertiary level of education.

In the November examination the overall pass rate for the Foundation Mathematics module in 2007 was 63% (see Appendix C1/C2). However, students in the collaborative learning group: 26 out of 36 students passed, achieved a pass rate of 72% (see Table 1). Of particular note is the marked increase of students in the 60-74% category, from 13.9% to 25%; an increase from 5 to 9. It is reasonable to assume that the majority of these students had been in the 50-59% range in June. There has been a notable improvement in the performance of those students in the middle order. This could be attributed to the pedagogic intervention and the fact that Foundation Mathematics is a year-long module. However, this may also be attributed to various other factors and requires further investigation.

Table 1
Comparison of marks for the experimental group

Range of marks	Pre-Test (March)		Examination (June)		Examination (November)	
	Number of students	%	Number of students	%	Number of students	%
75+	1	2.8	1	2.8	1	2.8
60-74	2	5.6	5	13.9	9	25
50-59	7	19.4	16	44.4	16	44.4
40-49	10	27.8	12	33.3	8	22.2
< 40	16	44.4	2	5.6	2	5.6
Total	36	100	36	100	36	100

CONCLUSION

Most of the students in the experimental group showed a significant improvement in their mathematics results at the end of the year. The students benefited from collaborative learning in more ways than one: improved their skills and knowledge in mathematics; made new friends; and learned about other cultures. Collaborative learning supports the notion that students should be socialised into the ways of talking and being actively involved in a community of mathematicians.

Further research should be conducted to verify the findings of this study. Firstly, what aspects of collaborate learning seem to enhance the students' performance in mathematics? Secondly, how can resistance to active learning strategies from staff and students be overcome? Thirdly, how can English second-language students from different backgrounds be accommodated in the curriculum and in the teaching and learning of mathematics?

REFERENCES

Barkley, E., Cross, P., & Major, H. (2004) Collaborative Learning Techniques (1sted.) San Francisco: Jossey-Bass.

Bernstein, A., Rule, S. & Simkins, C. (2007) Doubling for Growth: Addressing the mathematics and science challenges in South Africa's schools. Johannesburg: Centre for Science Development. http://www.nuimm.ie/staff/dpringle/igu/reports/South_Africa2.pdf (Accessed 23 April 2011).

Brodie, K. (2007) 'Dialogue in mathematics classrooms: beyond question and answer methods' Pythagoras 66 pp.3-13.

Broere, I., Geyser, H.C. & Kruger, M. (2002) 'Technology development: imperatives for higher education' South African Journal of Higher Education 16(3) pp.5-12.

Davis, B.G. (1993) 'Tools for Teaching' <http://teaching.berkeley.edu/bgd/collaborative.html> (Accessed 02 March 2007).

duPreez, J., Steyn, T. and Owen, R. (2008) 'Mathematical preparedness for tertiary mathematics – a need for focused intervention in the first year?' Perspectives in Education 26(1) pp.49-62.

Felder, R.M., & Brent, R. (2007) 'Sermons for Grumpy Campers' Chemical Engineering Education 41(3) pp.181-182.

Gokhale, A. (1995) 'Collaborative Learning Enhances Critical Thinking' <http://scholar.lib.vt.edu/ejournals/JTE/jte-v7n1/gokhale.jte-v7n1.html> (Accessed 6 June 2007).

Hartman, N. & Warren, D. (1994) 'Perspectives on a framework for curriculum development created for use in the faculty of social science and humanities' Paper

presented at the Conference: Challenging Educational Policies and Practices. Durban, South Africa.

Holtman, L. & McKenzie, B. (1994) 'Pre-Instruction & Post-Instruction Testing: assessing students existing conceptual knowledge & predicting their academic performance' Paper presented at the Conference: Challenging Educational Policies and Practices. Durban, South Africa.

National Council of Teachers of Mathematics.(1991) Curriculum and Evaluation Standards for School Mathematics. NCTM: Virginia, US.

Ngaka, W. (2004) An inquiry into the dynamics of intergenerational learning in Urcoda's adult literacy class in Arua district, Uganda. Unpublished Thesis. University of KwaZulu-Natal, South Africa.

Phurutse, M.C. (2005) Factors affecting teaching and learning in South African public schools. Cape Town: HSRC Press.

Schroeder, C. (1993) 'New Students - New Learning Styles' <http://virtualschool.edu/mon/Academia/KierseyLearningStyles.html> (Accessed 20 May 2008).

Setati, M. (2008) 'Using Language as a transparent Resource in the teaching and Learning of Mathematics' Pythagoras 67 pp.14-25.

Simmons, M. (1993) The Effective Teaching of Mathematics. Hong Kong: Longman Group UK Limited. Smith, B.L. & MacGregor, J.T. (1992) http://www.google.co.za/search?hl=en&source=hp&q=Smith%2C+B%2C+L.+%26++MacGregor%2C+J%2C+T.+%281992%29.+&btnG=Google+Search&meta=&aq=f&aqi=&aql=&oq=&gs_rfai= (Accessed 20 July 2008).

Tinto, V. (1997) Learning Better Together: The Impact of Learning Communities on Student Success. <http://www.mccli.dist.maricopa.edu/fsd/c2006/docs/learningbettertogether.pdf> (Accessed 20 July 2008).

Vygotsky, L.S. (1978). Mind in Society. The Development of Higher Psychological Processes. Cambridge, Massachusetts: Harvard University Press.

Webb, N.M., Nemer, K.M. & Ing, M. (2006) 'Small-group reflections: Parallels between teacher discourse and student behavior in peer-directed groups' Journal of the Learning Sciences 15(1) pp.63-119.

Weimer, M. (2002) Learner-Centred Teaching. San Francisco: Jossey-Bass.

Wenger, E.(1998) Communities of Practice.Learning, Meaning, and Identity. Cambridge: Cambridge University Press.

Wolmarans, N., Smit, R., Collier-Reed, B. & Leather, H. (2009) 'Addressing concerns

with the NSC: An analysis of first-year student performance in Mathematics and Physics' Proceedings of the Conference of the South African Association for Research in Mathematics, Science and Technology Education, Durban pp.276-286.

Wood, L. & Free, L. (2004) 'Made to measure foundation programmes' The Value of Academic Development for Higher Education Conference Proceedings of the South African Association for Academic Development. Port Elizabeth, South Africa pp.242-250.

APPENDIX A

CL TASK USING THE GSP

1. Factorize : $2x^2 - 5x - 18$ and $42x^2 - 96x - 24$ (4)

2. $\frac{x^2 - 3x - 4}{x - 1} \leq 0$ (6)

3. Solve : $2^x = \frac{x}{2}$ (5)

4. Determine the max and min values of $f(x) = x + \frac{2}{x}$ (5)

Total: 20 marks.

APPENDIX B

Instrument: Focus group interview:

1. Describe how you experienced Collaboratively Learning of mathematics :
(discuss what worked well, your interaction with your group members, your
learning experiences etc...

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2. Where there any problems / conflicts? If, so discuss...

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3. Would you recommend CL for foundation students next year?

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4. Any other comments/suggestions you would like to make?

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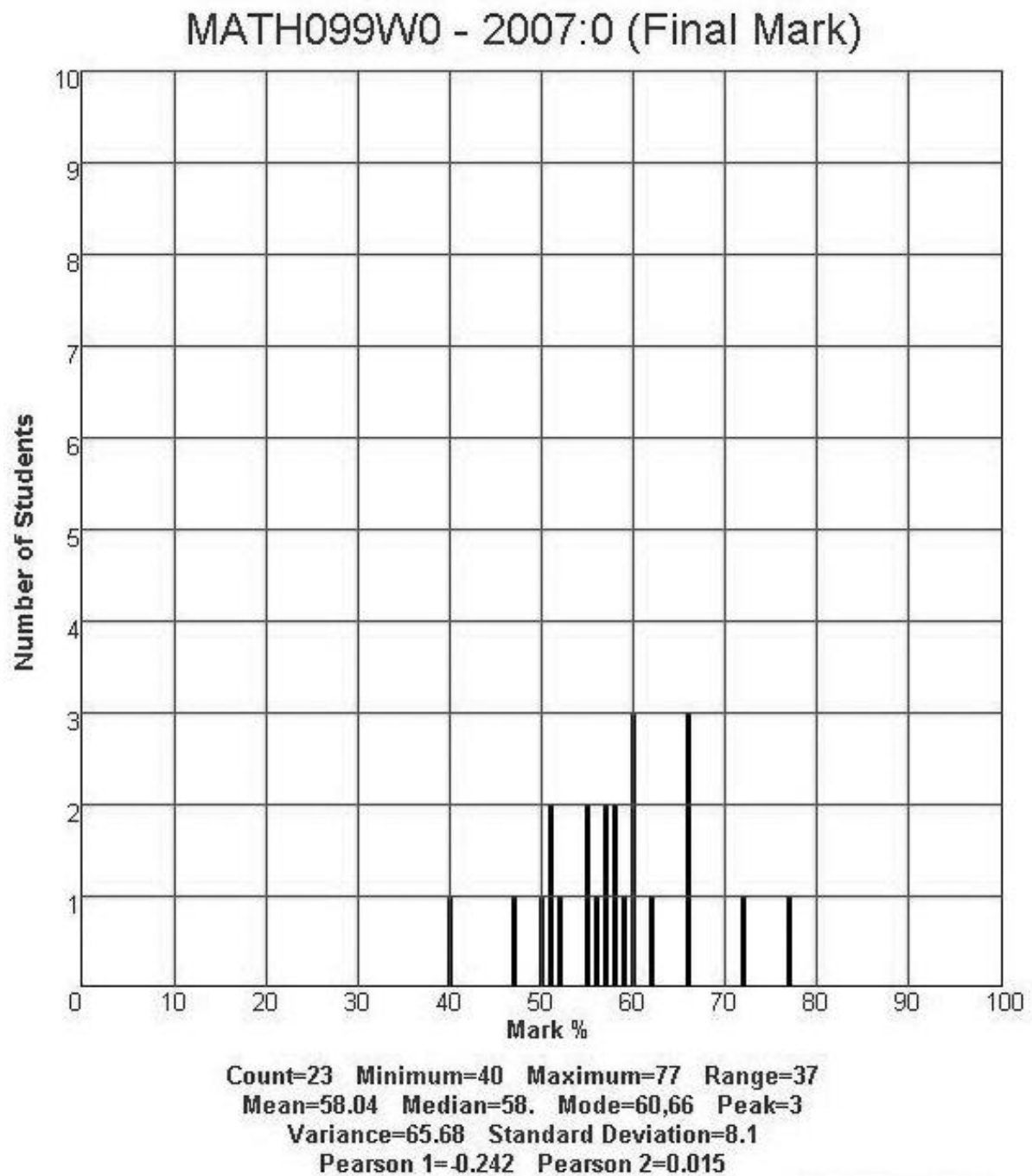
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Thank you once again for your participation and co operation. 25 July 2007

APPENDIX C1

MATHS 099 EXAMINATION MARKS



APPENDIX C2

MATHEMATICS 199 EXAMINATION MARKS

