TOWARDS A 1-TO-4 MODEL FOR MENTORING MATHEMATICS LEARNERS IN SOUTH AFRICAN SCHOOLS

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This paper reflects on an innovative partnership that Tshwane University of Technology (TUT) has initiated with WallStar (pseudonym), a South African high school adopted by TUT. The partnership involves TUT's mathematics education unit working with the school to mentor Grade 10 learners and develop their mathematics learning through interactive group strategies. We report on the initial interactions between the students and the school learners, and demonstrate that taking a multi-pronged approach to learners' mathematical learning not only helps to deepen and broaden the experiences and knowledge learners need for learning and understanding of mathematics, but also helps us to understand contextual issues related to education in complex learning systems such as we are typically faced with in township schools in South Africa.

Introduction

We describe here an innovative partnership that Tshwane University of Technology (TUT) has initiated with a nearby high school in South Africa. We begin with comments on what we regard as innovation, what partnership in education and in mathematics education entails from our own contextual perspective, and then frame our discussion on what we believe counts as "innovative partnership". We then describe the partnership that has emerged and comment on the unique features of this partnership. Furthermore, because this partnership is centrally about mathematics, we elaborate on the general approach we have taken in this partnership and zoom-in on one activity with learners which exemplifies what it means to engage with concepts from a modeling of reality.

Partnerships and innovations in education

The literature is replete with a range of innovations in education, both government or individually initiated. There are also many forms of partnerships in education, and partnerships in mathematics education, that have emerged and continue to inform and shape curriculum implementation and delivery, especially in the developing world. However, what counts as innovative partnerships depends on the contexts involved. Within the South African setting, the uniqueness and innovative nature of the partnership that we are reporting here lies in the fact that TUT's mathematics education unit has started working with a school's Grade 10 learners and will continue mentoring those learners until they reach Grade 12, the end of high school. The Unit has also invited and is mentoring a group of 30 mathematics education students to act as tutors to learners. Most importantly, each university student is allocated a group of 4 learners, a leadership dimension which is at the core of the partnership activity. The most critical and innovative aspect of this initiative involves this academic leadership dimension, where each student is given academic charge of a small group of learners of mixed abilities. The students are expected to maintain regular interactions, both formally and informally, in order to mentor, assist and build up learners' mathematics knowledge.

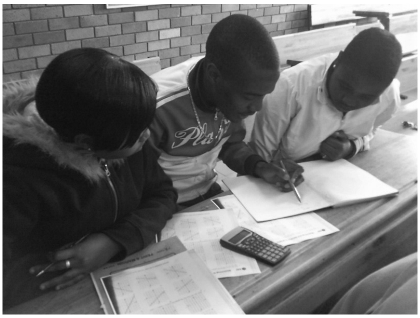
Mentoring

At the beginning of the partnership, the key question was: "If we mentor students, what would we be mentoring them on and how? We also had to make choices on what to mentor school learners on, and how, and most critically, how many learners would be involved and from how many schools. A decision was made to focus on one school and one group of learners, Grade 10, the first grade at the Further Education and Training phase of South Africa's new education system. We were also aware that a partnership like this one was only going to become better resourced if it involved a critical mass of people in the university, students in this case, who had mathematics and school mathematics teaching as their core current and future activity. We saw that preparing students for mentoring/tutoring learners would not be the only outcome but key of the achievements we wanted to gain.

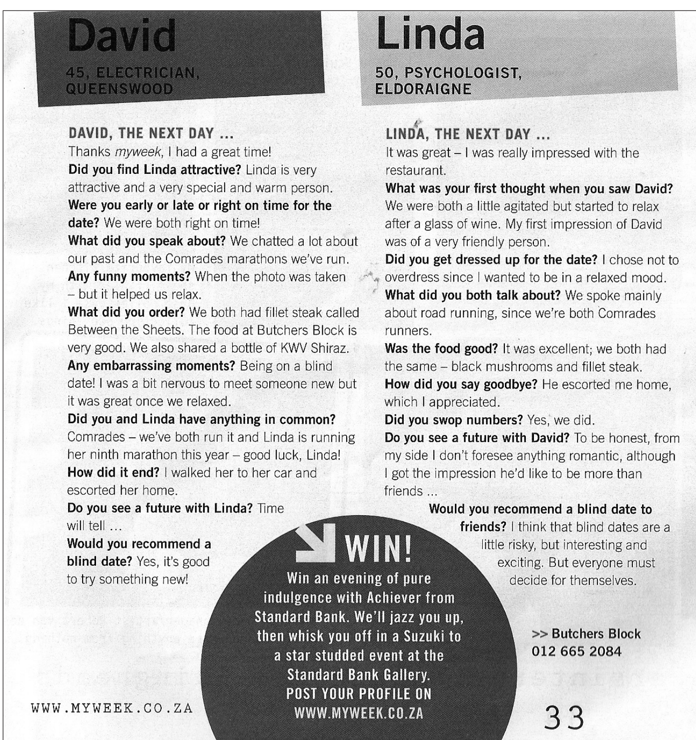
We need to say again that the allocation of learners to tutors was the most critical and innovative aspect of this partnership. Each TUT student is given academic charge of a small group of learners. This way of working in teacher education is rare. It is not common to see students being given such a role in typical pre-service teacher education programmes in universities. The closest we have observed relates to activities where pre-service students are asked to conduct case studies of some learners during teaching practice. This way of working is constrained because it is often packaged under the student assessment umbrella. The only contact students have with learners is during teaching practice periods and rarely afterwards. Informal interactions may occur with learners afterwards, but these interactions are often spontaneous and *ad hoc*.

In this project, student-mentors will have regular interactions, both formally and informally, in order to continually assist learners and build up learners' mathematics knowledge. This way ensures a longitudinal approach to mentoring.

In July 2009, initial interactions involving student-mentors and learners occurred. The first form of interactions involved learners themselves in the context of a group mathematical activity structured as part of a five-day mathematics programme at one of TUT's campuses. Interactions also occurred between learners and university setting (management and leadership) and with university students. A key innovative aspect in the nature of the activities given to learners involved what we called a "Fouring Activity". The fouring activity was an illustration on *modeling*. After having dealt with the real number system, we wanted to extend learner understanding by asking: "what is a number?" "What is a 4, and can you see a 4? And what does it look like when we see it?" A deeper question with one of the student-mentors arose: "Can a 4 speak to us? Can a 4 say 'you are seeing me?"



The Grade 10 learners were given a magazine called "MYWEEK" and asked to: 'Look through the magazine; focus on page 33, and write down how many 4's you see on that page'. Page 33 (see figure below) concerned a scenario: "Blind Date".



David

45, ELECTRICIAN,
QUEENSWOOD

Linda

50, PSYCHOLOGIST,
ELDORAIGNE

DAVID, THE NEXT DAY ...

Thanks *myweek*, I had a great time!
Did you find Linda attractive? Linda is very attractive and a very special and warm person.
Were you early or late or right on time for the date? We were both right on time!
What did you speak about? We chatted a lot about our past and the Comrades marathons we've run.
Any funny moments? When the photo was taken – but it helped us relax.
What did you order? We both had fillet steak called Between the Sheets. The food at Butchers Block is very good. We also shared a bottle of KWV Shiraz.
Any embarrassing moments? Being on a blind date! I was a bit nervous to meet someone new but it was great once we relaxed.
Did you and Linda have anything in common? Comrades – we've both run it and Linda is running her ninth marathon this year – good luck, Linda!
How did it end? I walked her to her car and escorted her home.
Do you see a future with Linda? Time will tell ...
Would you recommend a blind date? Yes, it's good to try something new!

LINDA, THE NEXT DAY ...

It was great – I was really impressed with the restaurant.
What was your first thought when you saw David? We were both a little agitated but started to relax after a glass of wine. My first impression of David was of a very friendly person.
Did you get dressed up for the date? I chose not to overdress since I wanted to be in a relaxed mood.
What did you both talk about? We spoke mainly about road running, since we're both Comrades runners.
Was the food good? It was excellent; we both had the same – black mushrooms and fillet steak.
How did you say goodbye? He escorted me home, which I appreciated.
Did you swop numbers? Yes, we did.
Do you see a future with David? To be honest, from my side I don't foresee anything romantic, although I got the impression he'd like to be more than friends ...
Would you recommend a blind date to friends? I think that blind dates are a little risky, but interesting and exciting. But everyone must decide for themselves.

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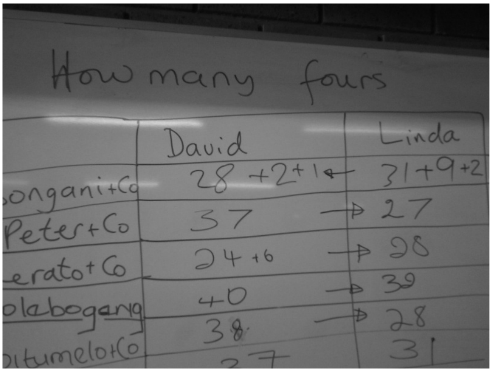
Initially, and as expected, most of the learners said they could see one 4, the number 4 in the term 0126652084 near the bottom right of the Figure. Upon reflection, some learners noticed that the number 8 in the term 0126652084 could be broken down to 4+4. This made them see another two 4's. A deep silence and sense of wonder emerged when we suggested that there could be more than three 4's in the scenario. The silence was broken when one learner said that another 4 could be obtained from the numbers 6 and 2 in 01266… by writing "6-2", giving a 4. The class proceeded in this way to generate many other 4's. They also noticed that we can also see that there are 4 letters in every four-letter word such as "next", "time" and "with", etc, in the scenario. This led to the whole class realizing and seeing that there are many 4's on the page, more 4's than the class was able to see originally. We came up with the term "Fouring" to mean the method we used for "looking for fours" in the way described above. This method led learners to compile the following table (see figure below) to indicate how many 4's each group saw on the page.



The table they generated showed that depending on how one sees, there will be differences in the number of 4's one is able to record. This ability to see, way of seeing (Brown, Hewitt & Mason, 1994), determines the kind of connections one makes with the world context they are interacting with.

Connections, awareness and learning

The notion of "connection" lies at the heart of key issues in mathematics (see for example, Forgasz, Jones, Leder, Lynch, Maguire & Pearn, 1996). Given their importance, connections need to be made an object of study (Mwakapenda, 2008). As can be seen in the data below, gathered from a questionnaire completed by student-mentors and learners during the winter school, connections are critically important because they make awareness and hence learning, possible. [Note: English is not the first language of student-mentors and learners involved. As a consequence quotes often contain a broken type of English. It would disturb the originality and flow of responses to continually add corrections].

As can be expected, participation in the winter school made it possible for student-mentors to gain academic knowledge (mathematics) and general knowledge about learners. A student mentor, SM11, observed: "As a tutor I have learned many things academically and generally about learners... It really helps me as a tutor to recognize how much potential I have... I enjoyed ... to be with learners doing mathematics and I recognize many things about the learners, the way they think..."

Some of the student-mentors saw the programme as preparation for their future teaching. SM15 observed: "Winter school is a preparation of my future I have to be in time everyday when I come to winter school because it is a foundation of my future as a teacher". In agreement, SM22 noted: "this programme gave me a good way of where, how to start when I go in teaching Mathematics in schools".

Participation in the programme contributed to a realization of their identities (who they are) in mathematics and mathematics teaching. SM19 observed: "I have realized the passion that lies beneath teaching and mathematics. I have always assumed that maths is about knowledge and understanding, but ... I have realized that I have gained the love and passion for it". Learners gained a range of strategies to use in working with problems in mathematics. Learner L5 said: "Before I came here in Winter school I knew only one way of finding the formular for number patterns... I [now] have many ways of finding the formular for number patterns... [I] thank also the [tutors] for giving me such strange skills".

Through the partnership, we introduced and connected learners to a new university community and how it works. This has enabled them to learn mathematics and to think about possibilities for their future education and careers in mathematics and beyond. L9 wrote: "I have known TUT but I didn't know it every well and I have known about the tutors who have educate[d] us very well... I also want to know where is the radio station because when I finish school I want to be a media programme[r]". Introduction to the TUT community made some learners to think about joining TUT after completing high school. L8 remarked: "The winter school has made me think that I will finish my matric and I shall be a student on this university. This week we have done things that our teachers would not teach us". When asked to say how they felt about those learners who did not attend the winter school, L8 said: "They have missed some interesting maths and they will never know how to make maths simple for themselves… they have missed some opportunities and they have missed to know some new interesting people".

Learners began to see themselves as belonging to a special community with special knowledge and attributes. Commenting again on learners who did not come to the winter school, L17 said: "they don't know what we do and they don't ON the pattern graph and they don't 'no' the whole number and the integers". L25 added: "I came here not knowing everything but now I understand a lot about numbers and how they work. I can also name them and also tell how they work... I understand a lot about natural numbers and *how it is like to know what they do*".

What makes connections possible?

We see several elements that are central to making connections possible. Critical elements are: *initiators* (staff and student-mentors) and core *participants* of mathematical activity, the learners, whose presence at the winter school made a difference. One of the student-mentors indicated that if all learners had attended, "their *presence* would have made a great *difference*" (SM11). For authentic connections to become possible there is a need for teachers and teacher-educators to use activities that go beyond the surface, e.g. activities that involve "reading and writing the world with mathematics" (Gutstein, 2003). Such activities not only "help learners on how to solve *problems in mathematics*" but are also concerned with teaching "how to *think critical* and *mathematically"* (SM11). We see this project as a starting point for making meaningful connections, and achieving and viewing change in the nature of mathematics in classrooms in our partner schools. This approach will be different from the "passive teaching and learning method[s] that are usually used in teaching mathematics" SM18.

Types of connections observed

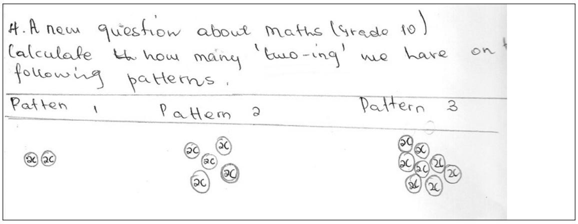
Our examination of responses student-mentors and learners gave in the questionnaire revealed four types of connections in relation to mathematics and participation in mathematics. The *first* form involved "Connections involving people" (i.e. *people-people* connections). SM6 wrote: "All of us (tutors, learners) were able to *connect* with everyone in the classroom". This winter school created an opportunity for learners to connect not only with other learners but also with their teacher and principal in a context different from the one they experienced at their school. The most useful and pedagogically powerful connections learners formed involved those that concerned their direct relationship with student-mentors. This connection is linked to another form that was of a technological nature. We created space for student-mentors and learners to interact with graphics calculators, another new dimension in this partnership project. In this connection, SM7 remarked: "I am now able to use the graphic calculator to *play* around with different problems or challenges… I know different strategies of conveying teaching-and-learning situation to learners using different teaching *media* and aids. Am able to teach educators and other students on the usage of the calculator"

A second type of connections that we identified involved situations where learners considered that everything they can possibly come across was related to mathematics. We termed these connections "Connections with a capital C". SM6 noted: "The maths has been planted in people's mind where I started to realize that o everything is maths – when I walk, I walk maths, etc". L20 wrote: "I know about number patterns and how to find them in everything I can imagine of ".

We identified a third form of connections involving situations when learners asked broader Questions about mathematics. We called this form: "Connections with a capital Q, i.e. Qonnection". L22's question below is illustrative of questions of a rare nature that learners asked. "My question is that who grouped numbers according to their classifications and their similarities, and who identified graphs".

The *fourth* form of connections concern what we called: "Connections that are about mathematisation: reading the world with mathematics (Gutstein, 2003). This form of connection involves creating a "new world" or reading the world with mathematics. We asked learners and student-mentors to: "Create a new question which is about maths in Grade 10" and to "Make sure that this question cannot be answered correctly by someone who has not attended this winter school".

SM7 responded as shown in the figure. The message here is: it is important how we connect mathematics to the world. The connections need to be made clear. For this particular connection, we see that the question posed by the mentor satisfies our criterion of a "new" question. It fits within the ways of working and thinking we introduced relating to the "fouring" activity described earlier. There are clearly challenges and complexities that are involved in making connections in mathematics that we need to explore further. We need to follow up these challenges in our future sessions with student mentors. SM7 was clearly able to formulate a "new" question based on what they had learned about "Fouring". Other responses that were similar to SM7's were as follows: "Is there any number patterns in the magazines" (SM13); "Look for the number 4 on this page and write how many 4's are there" (L6); "Find the fours in your maths book and explain what Apploximetly mean in 'Sepedi' Not in English" (L14); "Do fouring on a magazine and show them" (L20); "How many fouls do you have" (L24); "Do the fouring" (L29). It is interesting to note that more learners than student-mentors formulated a question that resembled the "fouring" activity. The way in which these questions were formulated would make it difficult for those learners who had not attended the winter school to respond correctly. Learner L11 commented: "They donnot know things like fouring, threeing, twoing, and oning".



We were able to see at least two categories in which the questions that learners formulated could be placed. There were responses which show that learners were able to or not able to create a new question. L21's comment below shows that some learners were not even sure what a question meant and how they would tell whether a question is a question. "I am having difficulties doing that but I know this one y = 2x – 4. I don't know if it is a question but it is one of the things that I know now how to approach". The second category involved students were able to create a question which was either clear or unclear in terms of what was intended.

Constraints to making connections a possibility

No payment was required for learners to participate in the winter school. As SM17 noted, "the winter school was *free* and it is not everyday that you find a free winter school at a university". For learners to be able to connect with others, there was a need for them to travel from their homes to the university (TUT). Getting to the university was clearly not possible for some due to a number of reasons. L16 noted: "Just like me I didn't attend for three day because of money. I felt very sad and other learners are at their homes wondering what are they doing wishing with all their heart and soul where could we get money to go and attend just like other learners". Financial constraints made travel difficult.

Language was also a constraint to reflection and making connections. As can be seen in the data shown here, lack of fluency in a language of expression makes it difficult to express their experiences in the winter school. Subsequently, this makes it difficult for us (researchers) to see what learners may be actually communicating. Due to the context in which the winter sessions proceeded, opportunities for using multiple languages (code-switching) were not afforded. Nevertheless, some learners "learned a lot" in spite of this constraint. L18 wrote: "I've learned a lot in winter school, they have been teaching us mathematics mix with English".

Moving forward: Strengthening the partnership

From the data presented so far, we can identify two ways in which we could take the partnership and mentoring project activities further.

Occasioning

There were moments when student-mentors and learners felt good about being in the project. Such moments need to be built on and modeled and extended further. In our follow-up meetings, we will be aiming to create situations where we deliberately work towards producing moments similar to or of a similar pedagogical power to those we have experienced in the first winter school. SM13 commented: "I felt like I was special to be with Grade 10 learners... The learners treated us like teachers ... I had the special days through the project with the grade 10's if I could [be] able to rewind future and turn back to the past I would turn back each moment with Grade 10's". Our explanation of why we will be proceeding with the project in ways like the above: rewinding the future and turning back each moment, will be informed by the notion of "occasioning" as discussed in Davis and Simmt (2003). Here, learning is viewed as an emergent event. According to Davis and Simmt, such events "cannot be caused, but they might be occasioned" (p. 147). So the concern therefore becomes one about creation: "how the mathematics teacher might occasion the emergence of a complex collective whose interactions and products are mathematical" (p. 149)Relating mathematics to the real world

The perspective guiding our mathematical work will be concerned with making connections. Our student-mentors have recorded that it is one of the productive and useful ways to proceed in mathematics education. SM 14 noted: "Help[ing] learners on the number patterns and functions it has made me to realize that *mathematics has to be related to life* challenges as far as possible". SM18 remarked: "These learners learned number patterns in a different way… e.g. knowing that stairs could be a gradient… I have learnt that mathematics is integrated or is found by real life situations. You can make mathematics fun by using *magazines*, *papers*". Adler, Pournara and Graven (2000) noted three forms of integration: "integration of the various components of mathematics, between mathematics and everyday real world knowledge; and where appropriate, across learning areas" (p. 3). While integration is desirable, the extent of the demands placed upon teachers makes integration less feasible. Our initial interactions with learners in this project have indicated that there are interesting possibilities for making connections in mathematics.

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