Becoming More Numerate: The Journey of Tania

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This is the academic numeracy journey of Tania, who participated in a research study that investigated the academic numeracy skills of nursing students. Tania is a mature aged woman, and her story represents many of such mature aged students as they journey into a largely unknown university culture. The data for this research came from student assignments, surveys, interview transcripts, emails and screencasts. To see the development in Tania's numeracy, this paper utilises the micro- and macrogenetic models from Valsiner, and his approach to dialogic self, We see Tania in different I-positions in particular of becoming a university student, becoming a nursing student and becoming numerate i.e. as being able to use mathematics confidently and competently in a nursing context.

In recent years the term numeracy has been used in schools and while it has been defined in that sphere as "to use mathematics effectively to meet the demands of life at home, in paid work, and for participation in community and civic life" (AAMT, 1998, p. 3), it often takes the guise of basic mathematics. However the use of mathematics within a school context is seen very differently from when it is actually used at work. FitzSimons (2006), using Bernstein's concepts of vertical and horizontal discourse, discussed school mathematics as vertical discourse, and work place mathematics as horizontal discourse. I propose that academic numeracy is somewhat in between these two but being influenced by both and often quite different from both. In the past I have defined academic numeracy in general (Galligan & Taylor, 2008). Here that definition is amended for the nursing context: a critical awareness which allows the nursing student to situate, interpret, critique, use and perhaps even create mathematics confidently and competently in the academic context. This paper is based on a first year nursing course aimed at improving students' academic numeracy and computing skills.

Background: The Nursing Context

In nursing, the numeracy skills required are considerable. In a typical day, a professional nurse is asked to undertake a multitude of tasks, many of which involve mathematics. Tasks include situating and interpreting a patient's chart (temperature, pulse and respiration rates), administering or monitoring medication (e.g. assessing the rate of a IV drip) , writing results on charts, and critiquing patients' needs (e.g. how much pain are they in). They also have to undertake these tasks confidently and competently. As Forman and Steen said in 1995 these contexts provide "a rich source of higher order thinking based on lower order mathematics' (p.221). However, the ways nurses complete these tasks are often quite different from what they typically learnt at university. (e.g. Hoyles, Noss, & Pozzi, 2001). At university nursing students are learning not only what nursing will be like, but also the demands of academic life, which requires critical thinking, problem solving, research and written communication skills, all of which can involve some mathematics. Research (e.g. Oldridge, Gray, McDermott, & Kirkpatrick, 2004; Rainboth & DeMasi, 2006) and my own background in supporting nursing students, have suggested that the nursing academic community is concerned with their students' level of mathematics skills not only for nursing but also for university.

Background: Theoretical Frame

In 2008 I discussed the role Valsiner's theory of human development (1997) could play in understanding academic nursing numeracy, specifically to identify what scaffolding is needed to assist teachers to allow students to understand academic numeracy and move forward (Galligan, 2008). Valsiner suggested that teachers 'create microsettings for the learners (within the wider activity context) where the learners can achieve the next moment of understanding themselves' (Cole & Valsiner, 2005, p. 309). Both he and Cole spoke of the concept of "obuchenie", loosely translated from Vygotsky as teaching/learning, where both the teacher and the learner are changed because of the activities organised (Cole & Valsiner, 2005; Cole, 2009). Valsiner also advocated the use of Vygotsky's method of double stimulation in a developmental quasi-natural experimental setting - the double stimulation coming from a Stimulus Object and Stimulus Means (with two stimulus means). In nursing for example, students are provided with a richly structured environment which can be restructured in a goal oriented way (Stimulus Object e.g solving a drug calculation). In this environment, the means to get to that object (Stimulus Means) is through Action Tools (e.g. a formula) accessed through a student's past experience etc. (Stimulus Means 2 e.g. having used the formula before but also other past experiences with mathematics) and the student's semiotic mediation with that Action Tool (Stimulus Means 1: thinking to use the formula or something else) and Stimulus Means 2. The general structure of the method in this study is to observe the initial, intermediate and final state of an event (or goal such as undertaking a drug calculation task), but the concentration is on the unfolding of the intermediate forms, both the ones that eventually turn into final forms and those that don't (described in Galligan, 2008). Within this unfolding attention is given to students' macrogenetic background (Joerchel & Valsiner, 2004) such as past mathematics experiences, network of student support; and students' ability to reflect and self-scaffold (Stimulus Means 2) and their thinking about how to act on the Stimulus Object. In the act of thinking, Valsiner drew from the dialogic self (DS) work of Hermans. DS theory is about semiotically self-regulating self in terms of "dynamic multiplicity of relatively autonomous *I*-positions" (Hermans, 2001). There are two visions of self – externally and internally. Internal positions could be *I*-the student or *I*-the mother. External positions talk about my tutor, my lecture notes, all in relation to *I*-the student; another external position may be my child, my home etc all in relation to *I*-the mother. This DS theory fits well into the adult learning/numeracy contexts. What may develop in the future are the *I*-student; *I*-nurse; *I*-the maths (or non) numerate person etc. To move these positions the teacher scaffolds students towards change and the student self-scaffolds so it is possible to move the *I*-positions.

Method

The research in which this study is placed is a quasi-experimental intervention case study within a first year first semester nursing numeracy/IT course. It takes a multi-method approach using a pre- and post-test, six computer marked tests (CMA's) and other assignments; observation notes; ten semi-structured teaching sessions and eleven interviews. It has three phases (Faltis, 1997) with each phase having data collection at three levels (Level 1: whole cohort of 1st year nursing students; Level 2: one tutorial class; and Level 3: three students). The first phase provides the baseline data of student academic numeracy; the second details the course, how it was taught, how students reacted to the

course and mathematical issues, the third phase investigates numeracy at the end of the course, and compares this to the other phases.

In this paper it is Level 3 that is being discussed via the collected data and a series of microgenetic studies of student numeracy from the interviews. The microgenetic part of the study is essentially phenomenological as it is centred on the human lived-through experience of students becoming more numerate. It is framed in an individual-socio ecological frame as it involves an active person; within a rich environment; the person acting on that environment; the teacher has an active guiding role; the aim is the transformation that person (Valsiner, 2007).

Results

Tania's Background

The first section of the nursing course was designed to encourage students to see themselves in three ways: Past numerate self (by writing about their past maths experiences); Present numerate self (by reflecting on pre-test answers); Future numerate self (by reading and commenting on an article on nursing students and numeracy). I will let Tania tell you part of her story from the reflection at the beginning of semester:

At school I hated maths. The only time I actually passed the subject in high school was when I had good teachers that actually took the time to work with the students who actually needed help and unfortunately those teachers were far and few between. One year I did manage very good results, but that was in total thanks to a teacher who was just awesome. He actually sat down and walked me through everything.

Later, in interview 5 she repeated this:

... [Teachers have an impact?] Negative impact, I've always grown up thinking I'm dumb at maths and science and if I had different teachers I would have done extremely well

She knows she "really needs to improve [her] basic mathematical skills", but already realises the importance of confidence as well as competence:

I expect at the end of this course that I will feel far more confident in basic mathematical work. I expect to learn a lot of invaluable material that will make life at university so much easier. The MAT course will give me the basic grounding in mathematics that I need and it will help me feel more confident that I will be able to complete the degree successfully (submission for assignment 1)

From the beginning Tania appeared to be aware of all that was asked of her and undertook tasks seriously. This could be partly due to her previous experience as a beginning Law student, so she knows what university expectations are. For example at the beginning of semester, students were asked to read an article about maths and nursing. Hers was one of the more reflective responses. Her insights into the reading already suggest she has an ability to synthesise an argument:

… It appears from the articles read that each student has a different way that will help them retain what they have learnt. There does not seem to be one single approach to teaching mathematics that works for everyone. And when it boils down to it, students and registered nurses have to be accurate in nursing calculations as it could cause severe illness or death in a patient that has been given an incorrect dosage (submission for assignment 1).

While Tania's past numeracy self was mainly poor, she did, through one teacher, realise there was some potential. Her present numeracy self sees this potential with her

growing in competence and confidence. Her future numeracy self in nursing sees her as proficient and accurate in nursing calculations. As well she sees herself as a university student and the work done this semester will directly affect this "self" in a positive way (i.e. "to make her life easier").

These different positionings of Tania help to create her mesogenetic story (Figure 1): how her meaning system is helping to structure her becoming numerate future system. Perhaps these "circles" of influence may change in size and thus shape their influence, (or not) on the future.
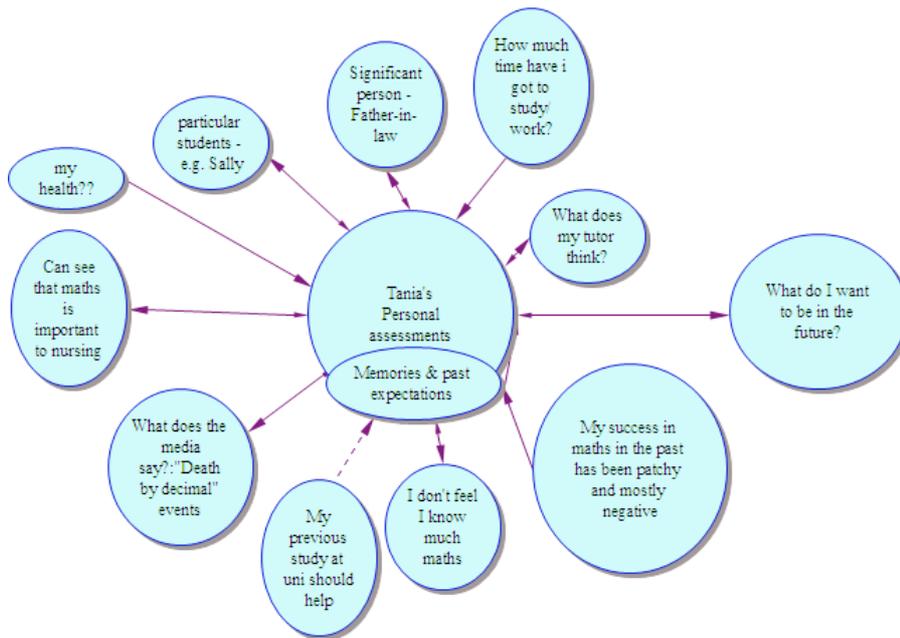
Figure 1. Tania's Mesogenetic model (based on Joerchel & Valsiner, 2004)

Her past mathematics experience may have had such a negative effect on her (Figure 2 (a) on the left) that even with a tutor's help, and with past university experience, she may not be able to improve her numeracy levels much).
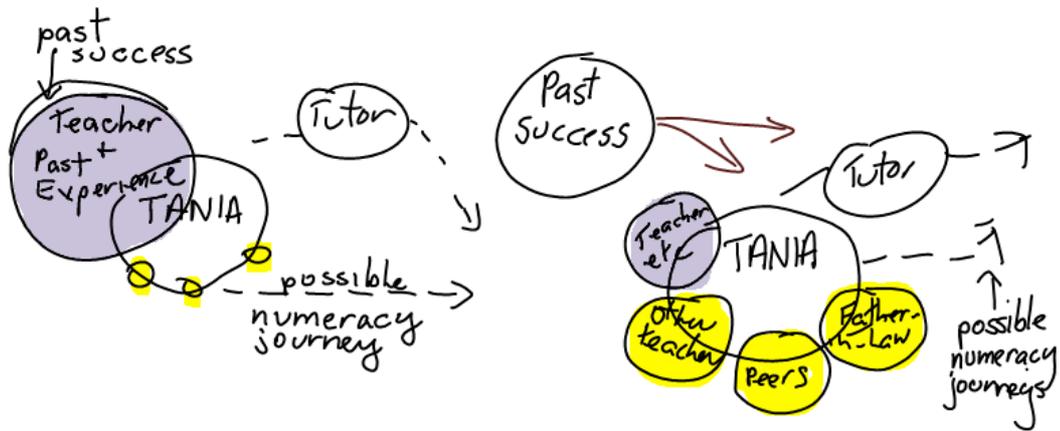
Figure 2. Possible trajectory of learning without harnessing (a) and (b) with harnessing of mesogenetic influences.

If however, an aim at first is to reduce the influence of negative past experience, then other positive influences, such as the memory of the good teacher, her peers telling her that she is "awesome" and her father-in-law being a sounding board outside university, can help her become more numerate (Figure 2(b) on the right) perhaps without tutor scaffolding.

Tania's Competence and Confidence Journey

The journey from A to B: The quantitative data from the pre-and post-tests and the CMAs give some insight into Tania's overall levels. Tania got 21/32 in the pre-test (the start of the journey at point A) and 29/32 in the post-test (the journey to B). Her confidence levels rose from an average of 2.58 out of 5 in the pre-test to 4.00 in the post-test. In the CMAs her average mark was 8.17 out of 10 and it ranged from 6 out of 10 in the graphs to 10 out of 10 for percentages and rates, and ratio and proportion. This data, however, tells nothing of how she became more numerate and whether she is, in fact, more numerate.

First the reflective comments from the pre- and post-test give a greater sense of development. Compared to other students, Tania reflected in detail, particularly in the post-test. I now turn to two examples from the qualitative data to investigate this journey.

At the beginning she had no idea about average "I haven't a clue how to work out an average" (confidence 1). At the end she was still wrong (didn't divide by 5) but there was a change:

> I'm seriously not sure how I got this one wrong. I've just recalculated it myself and realised when I sat the exam I must have done something wrong with my calculations on the calculator. Be more careful next time and double check what I consider is the right answer.

In terms of Double Stimulation, the first scenario, where B is the Stimulus Object (i.e. the average problem) promoted by the researcher, Tania simply stops and says she hasn't a clue. In the background (Stimulus Means 2) all her past experiences of mathematics blocks any attempts to move forward and she simple stops thinking (no SM1).
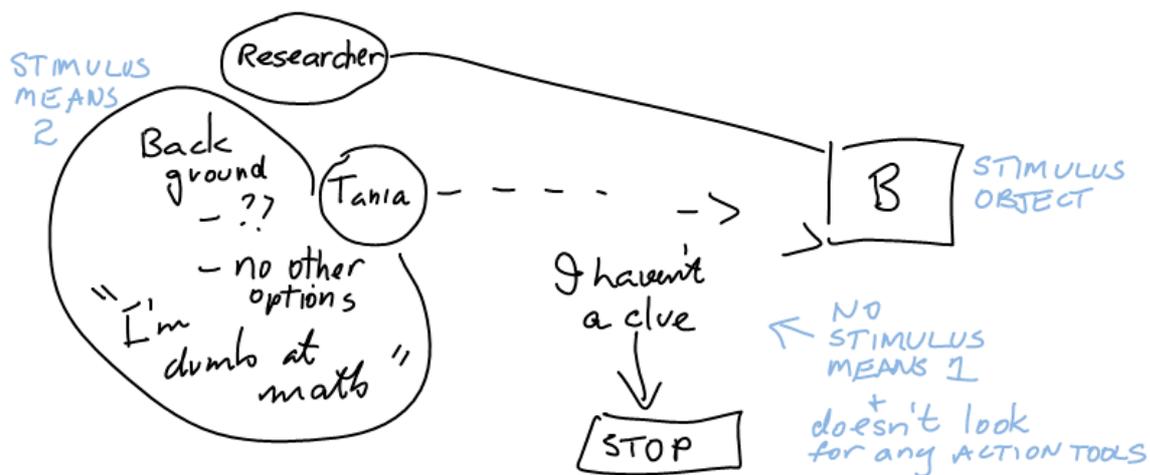
Figure 3. Double stimulation scenario with no development

However in the second scenario, with use of new knowledge and access to other meta-skills such as checking, feeling she should get it right etc (Stimulus Means 1), the background negativity shrinks and she uses other tools to think about the problem. Her confidence is still 3, which means she still must feel some doubt in her ability. Now instead of saying got it wrong and do nothing, she is surprised she got it wrong, has the wherewithal to check, then thinks about what she will do with such problems in the future.
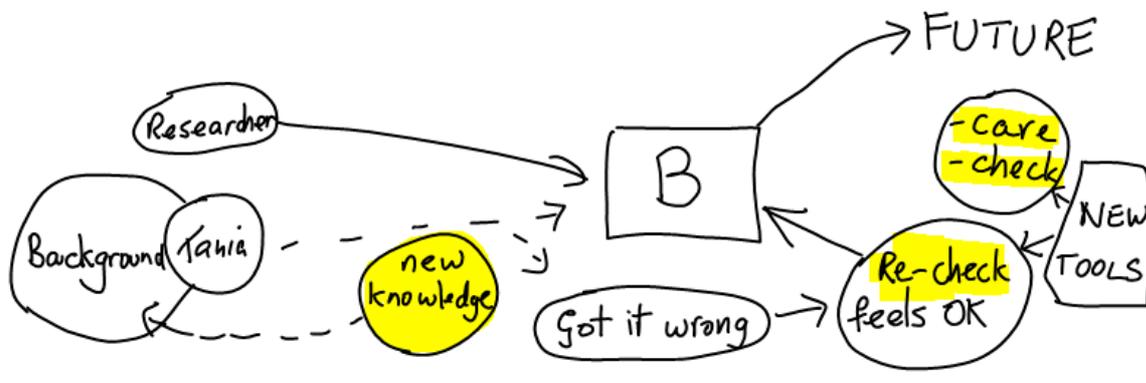
Figure 4. Double stimulation scenario with development

The second example is a question on drug calculation she had "no idea how to do this" with a confidence of 1 in the pre-test. In the post-test she was correct and was looking to her future numerate self. She didn't complete the confidence level but said:

> I am not fully confident with this type of question yet. I definitely need more practice questions like this to feel more confident. I will have to look into this. I am hoping that the medical calculations subject I will be doing next semester will ease my mind and show me how to do these types of equations with ease.

In each of the answers to the pre- and post-tests and the CMAs during the semester, confidence levels and comments help to create a picture of Tania's numeracy journey.

There are still errors and these errors show that her numeracy journey may not be complete, at times she doesn't read correctly, and there are some aspects that are still troublesome, but overall there appeared to be an improvement in confidence and competence. There is still also some scaffolding needed (e.g. she still refers to notes) and some doubt in some questions but there is an overall gain in her ability to trust herself. At the end of semester survey she wrote:

> Absolutely fabulous. learning maths skills that I never even understood in primary school or high school. I can't think of anything [improvement in course] at present...The mat class was awesome. It really helped me realise I could learn some maths.

From these reflections a picture of students' possible next steps is starting to emerge. The action of learning a concept can move from the periphery into the students' knowledge, and can be reflected and promoted, it can also lead to checking and thinking, confidence, transformative thinking about broader maths or nursing issues or thinking of "*I*" in a new light. There also may be other thoughts or actions present or possible and these may be promoted or not or reflected upon or not.

There were many times along the way where she struggled and asked questions of the course, of the mathematics and of herself. In these sessions I can see more intimately her relationship with the various aspects of mathematics. In some aspects of mathematics, I can see her grow from no understanding to quite good levels of understanding; in others she oscillates between knowing and reverting back to previous states.

If numeracy is about competence and confidence and about being able to situate, interpret, and critique mathematics, then Tania is showing signs of this. In the next semester when she came to a session with me about her solution to a problem, she has this feeling if something is wrong or the answer is too much or too little (line 184):

| 184. | Tania | I'm beginning to. I'm not 100 per cent but it's starting to gel because at least – I mean one thing I'm finding that I'm happy with is that I might be doing a calculation the way that [the lecturer] taught us and then going no, the answer – I look at the answer and I go no, if I was a nurse I would realise there's something wrong here..... So I'm beginning to realise that even though my calculations aren't always correct, I'm beginning to see if something looks to me to be way too much or way too little. Then I realise alright, I'm obviously doing something wrong with my calculations... I was trying to explain that to [the lecturer] because he was just saying that we should know all this kind of stuff automatically and I said but we don't. Not everybody is good at maths. But at the same time I've beginning to realise when something looks wrong.. |

The next day in the second session with her, there was a conversation about drug calculations. Two issues emerged. The first is the fluency with which she now speaks, and the second is the error in reading, which she is still occasionally making. Below I have also included my notes on the conversation.

40.	Tania	100 mg per kilo per day and the patients weight is 30 kg so i've got 100 x 30 3000 mg so is 3000 mg divided by strength in stock is 300 mg x 2 = 20 ml per day then I was a little bit unsure about that needed for 2 doses one i am wondering if that 10 ml per per dose or whether it is 40 mls per day was unsure about that one	She is reading this out and is reading "day" instead of "dose" She should have said 20 mg per dose
41.	Facilitator	well this is per dose this is 100 mg per kilo per dose	
42.	Tania	OK so it's a bit different	
43.	Facilitator	And you wrote down day	

44.	Tania	when i come to 20 mg 20 ml does it mean 20 mls so is it does that mean its 20 mls times 2 is 40mls per day yeah	And picked up straight away what she had done
45.	Facilitator	So what you have is 100mg per kilo per dose, so then you've multiplied the 100 mg by the 30 to get 3000mg That's 3000mg per dose to get the 3000mg you have to give them 20 mls (yes) per dose	
46.	Tania	So its 20 ml per dose so 40 ml per day [yeah] allright [2 doses] 2 doses see i had here so i calculated it correctly yesterday I had 40 mls today i had 10 ml and i was thinking today is this one right or is that one right?	Must have done this yesterday correctly and was checking
47.	Facilitator	the clue is this here	
48.	Tania	per dose i didnt actually pick up on	
49.	Facilitator	you did you wrote day ..yesterday you must have had dose. Every word is important.	
50.	Tania	hum COOL ....equals 40 mls per day (writing it) COOL thank you!	

This drug calculation question was quite complex and she was able to do most of these. She is now reflecting on and checking her work (line 46), but the error was in reading.

Conclusion: Tania's Journey to Date

If Tania's journey is written only from results of tests, then her journal is bare and static. If the scaffolding moments are added to the picture and analysed, at the same time incorporating the constraints and possible future states, a much richer dynamic journey can be seen. At various points in Tania's present (in 2008) the scaffolding phenomena were analysed. External constraints such as the teacher, the material, the environment interacting with internal constraints such as her *I*-positions, the way she was utilising her background of experiences, and acting on the environments all direct (but don't determine) to possible future states.

At a particular point in time it may involve some combination of these. For example if Tania is solving a drug calculation she may gain a bit more understanding of the concept; she may now automatically check her work, but her confidence is such that there is no effect on it, but it may add to her thinking of herself as the new numerate "*I*". What may emerge is a new merged action that automatically incorporated a few of these actions such as checking, understanding and self-scaffolding.

The approach utilising developmental theory of Valsiner, recognises the complex dynamic nature of "obuchenie", the multitude of decisions that a student may make in the course of learning and the influence of a students' mesogenetic processes on learning. Both the constraints and the promotions that a teacher puts in place can assist or inhibit learning, as does the student's own constraints and promotions assist or inhibit learning. In Tania's case, while her background included some negative influences, her own self-scaffolding and her positioning within the learning helped her become more academically numerate.

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