Challenging the Mindset of Sammy: A Case Study of a Grade 3 Mathematically Highly Capable Student

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This case study narrative reports on the journey of *Sammy as her mindset as a learner of mathematics is challenged. Often students who are mathematically highly capable are viewed as being privileged, they are rarely placed with the cohort of struggling students. Children like Sammy who are mathematically highly capable or gifted, however, are simply students who learn differently and therefore require a different type of teacher support. [*Sammy is a pseudonym].

> I think the problem is that she is really good at everything, and she's always been good at everything, and she doesn't know how to fail. It freaks her out completely, and she won't even get close to it because at the first little thought that something's going to go wrong she'll just shut down. (Sammy's teacher)

Generally students who are considered mathematically gifted or highly capable are not perceived as being classroom strugglers. Students categorised as 'vulnerable' or 'at risk' are most likely to be those who are not achieving minimum standards, those who require intervention or specialist assistance to help them 'catch up' to their peers in order to be able to participate successfully in the regular classroom (Gervasoni, et al. 2013). This study, however, considers the reality that there are students who, even though they may be highly capable mathematically, may in fact be vulnerable in terms of realising their true capabilities within the classroom. Indeed, it may be *because of* their unusually high natural aptitudes for understanding mathematical concepts that they develop a skewed view of what the process of learning entails, which in turn may stifle further learning opportunities.

Sammy is a case in point. Sammy, an eight-year-old, Grade 3 student, was a participant in a research project, 'Supporting the learning of students who are mathematically highly capable or gifted'. She proved to be a girl with issues in terms of perception of herself as a learner, which was curtailing her ongoing learning potential. This paper is her story: a story of how Sammy began to transform, through targeted teacher intervention, her self-limiting mindset to a much more confident and positive mindset.

Context

Classroom teachers have the responsibility to understand and cater for the learning needs of all students in their classes. This is essential for students who are mathematically gifted even though, or maybe because, these students are already successful in mathematics.

During the past decade there has been educational research focusing on identification of mathematical giftedness (e.g., Bicknell, 2009), on understanding mathematically highly capable students and how they learn (e.g., Leder, 2008), on providing suitable programs for them (e.g., Chesserman, 2010) and best approaches for teaching them, for example, differentiation (Kronburg & Plunkett, 2008), and acceleration (Hannah, James, Montelle & Noakes, 2011). However, the discourse about *why* it is necessary to consider the specific needs of mathematically highly capable or gifted learners has historically been based around benefits to society and our "globally competitive economy" (Office of the Chief

2015. In M. Marshman, V. Geiger, & A. Bennison (Eds.). *Mathematics education in the margins* (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia), pp. 477–484. Sunshine Coast: MERGA.

Scientist, 2014), with provision for the gifted even being described as "human capital development" (Ibata-Arens, 2012, p. 3). Thankfully this is beginning to change. In the latest Victorian Government Department of Education's *Strategy for gifted and talented children and young people*, the benefits to the individual are highlighted first "The chance to realise their potential, pursue a passion and develop a love of learning…" precedes the more common general benefits to society, "…gifted and talented children and young people are the potential leaders of tomorrow" (DEECD, 2014, p. 5).

Developing a 'love of learning' is a necessary element of 21st Century education. In an ever-changing technological era where types of jobs for future school leavers is highly unpredictable (Robinson, 2006), students need to learn how to continue to learn beyond the classroom. Unfortunately classroom environments can actually paint a skewed picture of what successful learning is, and what it feels like. Without providing students with work that requires perseverance and sustained personal effort we run the risk of turning naturally successful learners into students who are intimidated and fearful of effort and initial difficulty (Williams, 2014). Children who are mathematically gifted or naturally highly capable may have attracted many positive comments from a very early age from parents, friends of parents, pre-school teachers, even complete strangers. It is normal for many adults in western cultures to recognise and want to praise children's mathematical abilities (Bishop, 2002). The problem that may develop, however, is that without praise directed at effort and perseverance exhibited in performing a task, and often children who are highly capable mathematically do not need to apply much effort or perseverance in early mathematics tasks, we may be inadvertently nurturing a self-limiting mindset: a mindset that leads to children avoiding failure at all costs, which may mean avoiding suitably challenging tasks, or the opportunity of learning something new (Dweck, 2006). The development of a self-limiting mindset in students who are mathematically highly capable or gifted could have severe consequences.

In this study, I was testing three conjectures about mathematically gifted students: (1) Mathematically gifted students who are not challenged sufficiently develop a limited view of the process of successful mathematics learning, which results in a self-limiting mindset, but this mindset can be changed; (2) Mathematically gifted students who possess a self-limiting mindset will require teacher support when approaching challenging tasks so as not to feel overwhelmed and/or distressed; and (3) With a positive mindset about themselves as learners, mathematically gifted students can be taught, or may only need to be given permission, to challenge themselves, by being creative, delving deeper, and exploring further their own curiosities. Sammy's story describes an initial analysis of my findings.

Sammy's Story

Sammy was identified as mathematically highly capable through a multi-faceted process: teacher nomination; independent analysis of previous mathematics assessments and work samples; a parent questionnaire asking about her prior-to-school mathematical aptitude; individual semi-structured interviews carried out with both Sammy and her teacher; and a one-to-one task-based mathematics interview, assessing her ability to perform novel and creative tasks (as opposed to assessing previously learned mathematics content). It is important to note that my research was not aiming to identify *all* mathematically gifted or highly capable students, only to identify a small number of students to follow in a case study.

I observed Sammy in four mathematics lessons in a one week period as a participant observer – asking her questions, suggesting further challenges, and providing support if necessary. This was followed by collaborative discussion with her classroom teacher, exploring suggestions for supporting Sammy's ongoing mathematics learning (see below). These suggestions were then implemented by the teacher within regular mathematics lessons over the following twelve weeks. Further classroom observations followed – three mathematics lessons in a one week period – with me as a participant observer. I then re-interviewed both Sammy and her teacher, and conducted a second one-to-one task-based mathematics interview with Sammy.

All interviews and in-class conversations were audio-taped and transcribed. Classroom observations were journalled, and student work samples were collected and/or photographed. This formed the data for a priori analysis.

Data analysis was based on the observation of classroom involvement and participants' perspectives, establishing themes for description, reflection and interpretation (Creswell, 2013). It consisted of making a detailed description of the case – supporting mathematical giftedness – and its context – within the mathematics classroom (Hébert & Beardsley, 2001). The study assumes a social constructivist framework which places emphasis on the role of others in the learning process, including an actively involved teacher and the shared experience of other children.

Sammy Before

In the initial one-to-one assessment interview Sammy presented as a bright, friendly, very self-assured girl. She answered questions quickly and confidently, even when she was incorrect she was very quick and confident with her answer. I was initially unsure just how outstanding her natural ability was, but in hindsight, it's possible she was 'playing it safe' with many of her responses, and answering quickly rather than being seen to be having to put in any effort.

When I asked her "How do you know someone is good at maths?" her reply was, "[They] always finish their work in time. They're always going 'done', and always get the right answer…" (Sammy, May 2014)

My first observation of Sammy in a maths lesson in her regular classroom was in mid-June. The lesson was about arrays (visualising multiplication), and the focus of the lesson was 'writing number sentences to describe arrays'. The introductory session covered what an array is [arranging dots/counters in equal rows and columns], and the class was then sent off to explore various quantities (12, 15, 18, etc.), using counters to make arrays, and writing number sentences to describe the different arrays they could make with each of these quantities. Sammy set to work quickly and quietly by writing down a list of number sentences – 12x1, 1x12, 3x4, 4x3, 2x6, 6x2 – and then dutifully drawing the arrays next to each equation. She was going through the motions, reproducing work she could already do quite confidently. And she was happy.

I decided to intervene to show her some other possibilities she could explore. I explained that I could see another number sentence that could be written for an array of 12 she had drawn (Figure 1): I could see three rows of three on the top and another row of three along the bottom – 3x3+3 (Figure 2). She immediately saw two rows of three plus another two rows of three – 2x3+2x3 (Figure 3), so I left her to see what else she could discover within some of the other arrays she had drawn. As I walked away I heard her exclaim to others at her table, "This is so cool!", and she eagerly set to work.

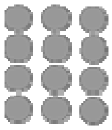
Figure 1. 12=4x3

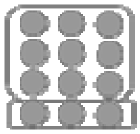
Figure 2. 12=3x3+3

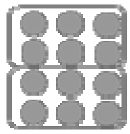
Figure 3. 12= 2x3+2x3

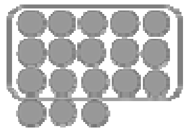
Figure 4. 18=3x5+3

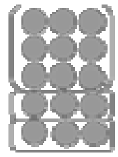
Figure 5. 15=3x3+3+3

When the teacher called the class back to the mat, Sammy was very eager to share what she had discovered about ‘array busting’, but what she chose to share was that she was able to write 18 as a number sentence: 3x5+3. Unfortunately, although the number sentence was correct, and what she drew certainly represented the equation (Figure 4), she had lost sight of the array focus. The dilemma was that the rest of the class was looking puzzled at her non-array representation, and some began to question it. To overcome the awkwardness of the situation I got Sammy to compare her drawing with a 15 array that was already drawn on the board and asked her to ‘bust’ the 15 array in the way she was trying to describe. She was a little flustered initially, but ended up with 15=3x3+3+3 (Figure 5).

It wasn’t until the teacher directed the class to the follow-up activity, and the students dispersed from the mat, that I realized that Sammy was sobbing! Initially she couldn’t explain what was wrong because she was sobbing so hard, but eventually pointed to the 18 ‘array’ on the board and choked out, “I can’t do it!” After some reassurance she eventually settled back to work, but reverted to writing and drawing basic number sentences for her arrays (16=4x4, 2x8, 8x2 etc.), and remained miserable for the rest of the lesson.

Sammy had been fascinated and excited about the possibilities of more complex array partitioning, but when the class discussion led her to believe she was wrong, she became highly distressed, and subsequent learning opportunities in that lesson were completely stifled.

From the interview with Sammy’s teacher it seems that this kind of reaction, while not an everyday occurrence, was not uncommon (I witnessed it twice in the seven lessons I observed), and it was the sort of thing that Sammy dwelled on…

> I said, "Why don't you try something else with that and doing the ‘explore more challenging things’", and she's like, "No, I think I'm ok with this." And she brought up that lesson [the arrays lesson], like from however long ago it was, and I was actually really surprised. But she had brought it up a few times since then, like I've heard about it a few times ... (Sammy’s teacher, July 2014)

Sammy also tended to be very self-critical. ‘I’m no good at maths’ was a regular utterance when she was asked a question she didn’t know the answer to immediately. Within the first 30 minutes of a lesson on ‘How many designs can you make that are 1/4 yellow and 3/4 red?’ she had uttered, "Let's do the easy ones first", “Oh my gosh, you guys are fast! How do you do it [come up with design ideas] so fast?" “I’m not very good at this”, “I’m not good at maths”, “But it’s too hard”, and “I can’t do this”, all the while successfully working on not only coming up with creative designs but also exploring and understanding non-contiguous three-quarters designs, and non-uniform parts (see Figure 6). This, however, was new territory for her that required some thinking and she constantly wanted to go back to ‘the easy ones’.

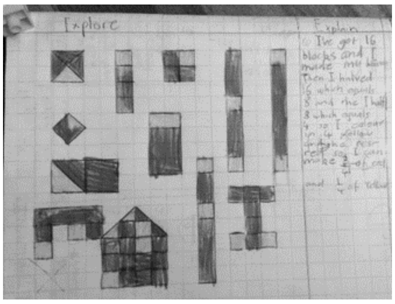

Figure 6. Sammy's $\frac{1}{4}$ yellow $\frac{3}{4}$ red designs

Sammy was undoubtedly highly capable mathematically. She learnt new concepts quickly, she was readily able to transfer new knowledge to novel situations, she was able to reason abstractly, and she was able to explain her reasoning to others (cf. Krutetskii, 1976). However, she seemed to have issues with having to put in effort, with not knowing the answer straight away, with having to think hard about a problem. These things, to her, seemed to be an indication that she was 'no good at maths'. The challenge with students like Sammy is not just in providing them sufficiently challenging work. Students like Sammy also need to be sensitively supported through these often foreign feelings of floundering, of cognitive conflict, that are, in fact, a necessary part of higher level learning (Roche, Clarke, Sullivan & Cheeseman, 2013). To us Sammy's responses of devastation and uncontrollable sobbing may seem extreme, but it is not uncommon for highly capable or gifted students to exhibit intense emotional sensitivity (Dabrowski & Piechowski, 1977), where every little setback is felt as earthshattering. These feelings are very real and these children need to be given strategies to help cope with their intense emotions.

The Intervening Period

The next stage in the study was to meet with Sammy's teacher and discuss together ways she could provide sufficiently challenging tasks for Sammy, and how to support her in this. Most of the suggestions discussed were useful and effective strategies for all students in the class. The following list was agreed upon:

- Establish a classroom understanding that learning requires effort and hard thinking, and that is what is expected in a mathematics class. Hard thinking is a good thing, not a sign that you are not good at maths.
- Establish that when I (the teacher) ask a question, I am posing a problem I want you to think about. I don't want a quick answer (I am not testing you). What I require is a well thought out explanation, the answer is the by-product of this.
- Model that there is always more you can explore. Teach them how to think deeper (if necessary); there is a skill in learning how to learn. Generate a classroom environment that values creativity. Encourage students (especially the highly capable students) to run with their own ideas. Constantly ask questions like "How are you challenging yourself?", "What's next?", "How can you be creative with this?" The aim is for these questions to become part of a student's own self-talk.
- Give them permission and time to explore and investigate further – to follow their own curiosities.

- Be aware of, and challenge self-limiting mindset statements such as “I’m no good at maths”, or “This is too hard”, as well as statements like, “This is easy!”, or “I’m bored”, or “I’m finished!”

Sammy’s teacher was already putting into practice task differentiation for varying abilities within her class. However, putting the onus of challenge, in part, onto the student who is mathematically highly capable allows for even further meaningful differentiation. Sometimes what we, as teachers, think will be challenging turns out to be either too easy, or just way too hard. Sometimes, something we think will be too easy turns out to be quite challenging due to misconceptions or gaps in their learning. It also avoids the tragedy of statements like, “At University they get you to actually learn things yourself, instead of school where they tell you everything and get you to do it a certain way…" by Jacob Bradd, on acceleration to university at age 14 (McNeilage, 2014, para 18). Or the advice to parents to allow their children ‘mental health days’, “…days on which gifted kids are given an opportunity to [stay home] to learn more. They don’t have to sit in a room waiting for the other kids to catch up. They can unfurl their wings and fly” (Bainbridge, n.d., para 8).

Sammy After

In the follow-up classroom observations with Sammy three months later, I witnessed a child who was more willing to take risks. She still became excited and animated when faced with new ideas to explore, but was now much more willing to stop and think through things that didn’t initially make sense. This allowed her to learn even more. Her teacher had also noticed this:

> … there was another time when she could have absolutely lost it – they were talking about recording the area of a certain object, so imagine they measured this bench and they recorded that it took 50 large playing cards. James, the pre-service teacher, was writing '50' and then 'large cards' next to it, and she [Sammy] is like, "and you should put like a little square on the top of it, it's a number 2 and it means squared," because she was trying to tell him about squared centimetres. And he was like, "but is this playing card square?" And she's like, “Well no ..." and then she made the connection that "Oh, it's actually centimetres squared because they are squares!", and that was the whole reason behind it. But usually she would just freak out because he said, "but that's not a square". (Sammy’s teacher in post interview, October 2014)

In this lesson, when the teacher questioned Sammy’s suggestion of putting ‘a little square on the top of it’, she stopped and reflected and was able to identify a critical concept about area measurement, that the unit of measure for measuring area is an actual square. This was in complete contrast to the previous lesson I had observed with arrays where she had an emotional meltdown because she thought she was wrong in front of the whole class.

The other very notable change in Sammy was her lack of negative comments such as ‘I’m no good at maths’. Not once in the three follow-up lessons observed did she mention this. When asked about this in the post interview Sammy said that her teacher had been helping her learn how to not say things like that, that her teacher had drawn up a chart to help her change her mindset, and she drew an example of the chart for me:

> …like, 'I can't do it', and she has all negative stuff here [indicating the left side of the chart], and then she reversed them here into positives [indicating the right side of the chart] to something like, 'I'll work hard to get the answer, but I might not be able to get it right just now'. (Sammy, November 2014)

When I asked if it was she was consciously choosing not to say ‘I’m not good at maths’, she stopped and thought and seemed quite surprised before exclaiming, “I *don’t* think it anymore…It’s just kind of worked like magic!”

When I asked her this time how she knew she was good at maths her response was, "I know I'm good at maths because I did that [pointing to a task she'd just persevered with for over 30 minutes] and I thought it was too hard but I did it!" (Sammy, November 2014)

Discussion and Conclusion

Sammy certainly appeared to have self-limiting beliefs about what it means to be 'good at maths'. To be good at maths she believed she needed to be able to work quickly and get the answers right. When we began to challenge her, even though she initially enjoyed the challenge, if she couldn't get it right straight away, or if she perceived she may have done something wrong, she immediately came to the conclusion that she wasn't good at maths, and this was quite distressing for her. Her 'safe' responses in the initial one-to-one assessment interview may also have been an example of underachievement due to this misconception.

The good news is that Sammy's self-limiting mindset was turned into a more positive mindset in a reasonably short period of time. However, this was a scary and sometimes overwhelming venture for her that required intensive and sensitive support from her teacher who had to learn to understand where Sammy was coming from, and how to deal with her hyper-sensitivities.

As far as encouraging Sammy to challenge herself by being creative, delving deeper and exploring further, there seems to have been quite a deal of 'unlearning' of what she believed was expected in the classroom. She has certainly come a long way in that she is now prepared to take risks and explore unknowns if suggested to her, which is a necessary first step, but she is yet to show any initiative in this.

The data reported on in this paper suggest that challenging Sammy's mindset about her beliefs about herself as a mathematics learner proved to be a challenging journey for both Sammy and her teacher.

> Probably one of the biggest things I've learnt this year is because she is really great at everything you wouldn't necessarily look at her and think "This kid's struggling" but she is probably struggling more than anyone in the class, but in a different way. She's been my biggest struggler this year. (Sammy's teacher, October, 2014)

There is much to learn and understand about students who are mathematically highly capable or gifted. Contrary to popular belief that they are a 'privileged' group who work easily without the need for help from the teacher, they are actually just children who learn differently and therefore may require a different type of teacher support. The classroom observations and follow-up interview demonstrated that Sammy's mindset had changed to a much more positive one, but this only came about due to the diligence and perseverance of her teacher who was prepared to learn as much as she could about things like hyper-sensitivities. As with so many things, prevention is better than a 'cure'. If more teachers were aware of the impact of not catering for students who are mathematically highly capable or gifted, in terms of making sure they understand that hard work, effort and perseverance are a normal and expected part of learning, it is possible we may see less underachievement in this cohort of students, and may even pave the way for happier and more successful adults in the future.

> It wasn't because Newton and Einstein were geniuses that they were successful, it's because they made the transition from learning, to thinking, to creating. (Jacob Barnett, 2012, 14 year old astrophysicist)

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