The Power of Creativity: A Case-Study of a Mathematically Highly Capable Grade 5 Student

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This case-study explores the impact of a 12 week in-class intervention designed to encourage creativity, inquiry and exploration as a normal and expected part of mathematics lessons, with a particular focus on supporting the learning of highly capable and gifted students. Fred is a mathematically highly capable grade five student whose personal learning focus in mathematics changed from simply 'getting the answers right' and striving for 'A pluses' to being more willing to think beyond the set mathematics task to include imagination and creativity.

This paper reports on a single case-study which was part of a larger multiple case-study project. The underlying purpose of the broader study was to explore ways that teachers can help facilitate the talent development of mathematically highly capable and gifted students. 'Capability' and 'giftedness' do not automatically translate into 'talent'. Talent emerges from giftedness through a complex developmental process via a number of influences, including teaching and learning opportunities *(*Gagné, 2003). Many highly capable and gifted individuals continue to work below their true capacity for many reasons (Gagné, 2015). If the view of education is to enable students to reach set standards, this is not necessarily a problem (as long as those standards are being met), but if the view of education is to enable students to reach their own individual potentials and personally become meaningful contributors to society, then this is an issue that needs to be addressed.

> School was easy. Too easy. Read the book. Answer the questions. Get an A. I never learned what hard work was. Or how to do it. Ability was enough.
>
> (Lofty, 2014)

The premise of this study is that an educator's role is to maximise student learning, to determine individual zones of proximal development and target learning and teaching experiences accordingly. "Gifted and talented students [as well as all other students] are entitled to rigorous, relevant and engaging learning opportunities drawn from the…curriculum and aligned with their individual learning needs, strengths, interests and goals" (Australian Curriculum and Assessment Reporting Authority [ACARA], 2015, para 1). The conjecture that was trialled with Fred, a Grade 5 boy at an independent school in regional Victoria, Australia, was that if mathematically highly capable students, as part of their overall mathematics learning, are given permission and/or strategies for extending their own mathematical curiosities we may be enabling them to become more self-actualising, autonomous learners (Betts & Neihart, 2010; Maslow, 1968; Subotnik, Olszewski-Kubilius & Worrell, 2011). The question for the study was what happens when mathematically highly capable and gifted students are given permission, and an underlying expectation, to *challenge and extend themselves* by being creative, delving deeper, and exploring further their own curiosities? This paper is part of Fred's story.

Background

> Gifted children are by definition creative…The discoveries they make about the domain [in which they show precocity] are exciting and motivating…Often these children independently invent rules of their domain and devise novel, idiosyncratic ways of solving problems. (Winner, 1996, p. 3)

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Winner's description of the gifted child is exciting and full of hope for both the child and society. This description may also explain why some teachers question just how prevalent giftedness is, or whether, indeed, it exists at all (e.g. see Boaler, 2015, who talks about the 'myth of the mathematically gifted child'). Gagné's (2003) Differentiated Model of Giftedness and Talent (DMGT) was used as the theoretical framework for defining giftedness for this study (see Figure 1). The DMGT explains why we may not be acutely aware of the highly capable and gifted students in our schools. Capability (which is innate) does not automatically translate into ability (which is developed). For innate gifts to be realised as talents, there need to be optimal intrapersonal factors and environmental influences. Further, for talents to reach a level of expertise or mastery there is a requirement of hard work and many hours of struggle and effort (Gladwell, 2008). Giftedness is not synonymous with prodigy. Not all gifted students will be experts; not all gifted students will even be high achievers; and, conversely, not all high achievers will necessarily be working at their full potential.

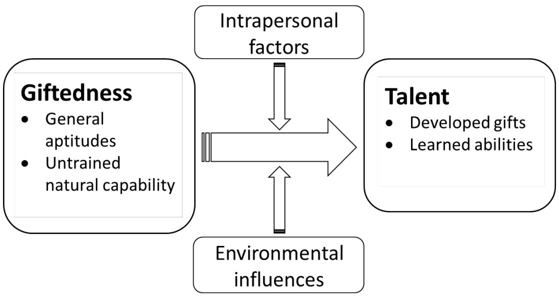

Figure 1. Simplified model of Gagne's DMGT

Being 'mathematically gifted', then, could be considered as being 'statistically different' in terms of an innate natural capability for learning and understanding mathematical concepts (see Figure 2). This being the case within any population of 100 students we should be seeing, on average, one to two gifted students (top 1-2%) and around five to eight highly capable students (top 5-8%).

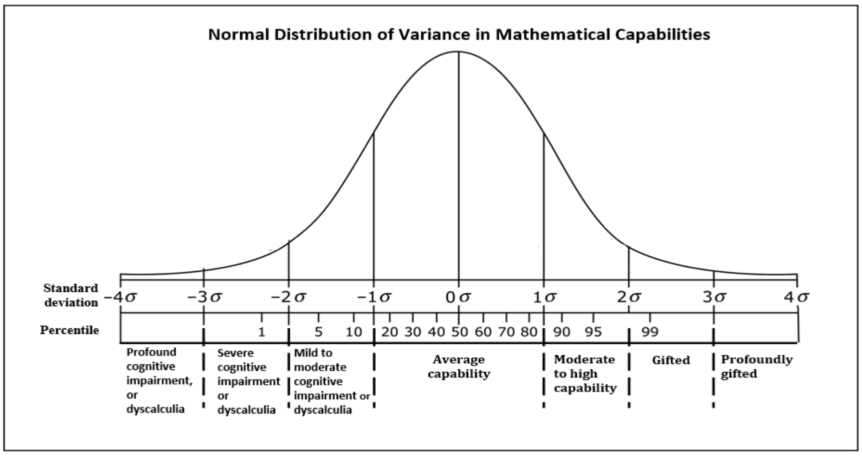

Figure 2. Normal Distribution of Variance in Mathematical Capabilities

Mathematically highly capable and gifted children aren't born knowing mathematics, but they learn concepts quickly and easily relative to the mean distribution of mathematical capabilities. This is not to say other students cannot learn and be ultimately successful in mathematics to the same degree, it just means that within any given grade level different students will be working within different zones of proximal development (see Figure 3). Betts and Neihart (1988, 2010) suggest that even high achievement is not a sufficient indicator that the gifted student is working at their full capacity. In fact, sustained high achievement may be an indication that the student is working within their current abilities rather than realising their learning capacity by working within their zone of proximal development.

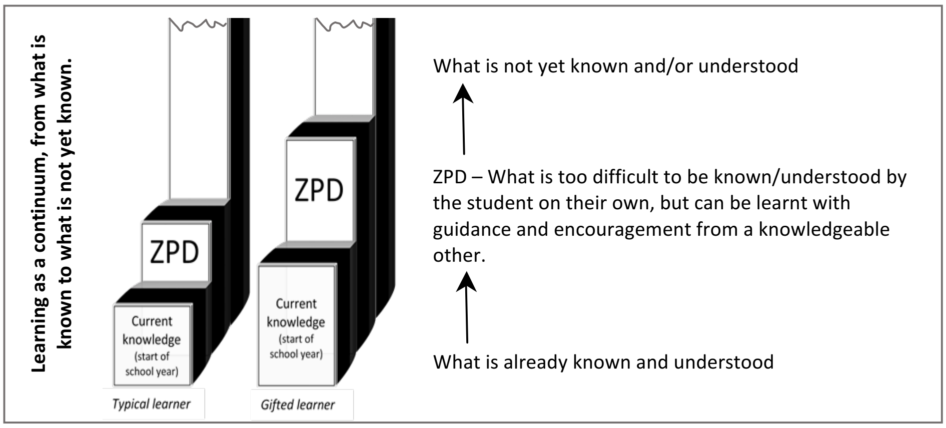

Figure 3. Zone of Proximal Development – gifted learner versus typical learner

What is needed, to be providing for mathematically highly capable and gifted students, is a learning environment that enables them to not only succeed, but to continue to learn, to develop as autonomous mathematics learners, and to have permission and time to generate new and innovative ideas from the things they learn and know (Barnett, 2012; Betts & Neihart, 2010; Winner, 1996).

Method

This paper reports on a qualitative case-study of Fred, a Grade 5 student at an independent school in regional Victoria, who had been nominated by his teacher and subsequently identified as being mathematically very highly capable. The identification process was multifaceted including interviews with both Fred and his teacher, a parent written questionnaire, previous mathematics assessments, classroom observations, and a specifically designed task-based mathematics interview. The mathematics interview was designed to identify students' ability to learn new mathematics concepts easily, to generalise new knowledge readily, and to reason using intuitive strategies in order to efficiently solve an unfamiliar mathematics problem beyond the scope of normal primary school curriculum content, all hallmarks of Krutetskii's (1976) observations of mathematically highly capable and gifted students.

Following the identification process, guidelines for supporting continued growth in the learning of mathematics in the classroom were discussed with Fred's teacher, for her to implement throughout an intervention period of approximately 12 weeks. Fred's teacher was particularly concerned about some of his insecurities and negative responses to challenge and was keen to get some ideas for how to better support his ongoing learning. She was very willing to take part in the trial intervention process.

The Intervention Period

Based on literature about effective mathematics teaching and learning and the learning needs of highly capable and gifted students, a list of expectations was used as a framework for intervention classroom approaches that Fred's teacher was to use and/or further develop in her mathematics lessons for optimising the learning environment. For example, expectations that 1) learning requires hard thinking and sustained effort; 2) task completion requires time, if the task is completed quickly and easily then minimal learning will have taken place; 3) mathematics is a creative process, there is always more to explore; 4) thinking outside the square, or beyond the set task, is something that is valued, specific permission to do this is not usually required. This final suggestion, the expectation of students to explore the mathematics of a given task further themselves, to set their own challenges (Betts & Neihart, 2010), was especially for, but not limited to, highly capable students.

The regular mathematics lesson structure established was to 1) solve the problem, 2) explain the solution, and 3) explore the mathematics further:

1. *Solve the problem.* This was whatever the teacher's normal classroom practice was. The mathematics task may be an investigation, a game, an open-ended question, a computer task, a worksheet, etcetera, which may or may not need to be differentiated for mathematical abilities. The expectation was that all students in the class would undertake the set task.
2. *Explain the solution.* This requires a different set of skills that need to be learned and developed. The main objective is to provide learners with the opportunity to develop the ability to explain and communicate mathematical ideas clearly in order to be able to work with others, and to have their contributions validated and valued. The ability to communicate findings and provide explanations is an important outcome of mathematics education (Knuth & Peressini, 2001). Again, the expectation was that all students in the class would learn how to explain their strategies and solutions in order to communicate their mathematical thinking, both orally and (occasionally) as written reports. The process of explaining and justifying solutions (how they worked the problem out, why they worked it out that way, and how they know their solution is correct) can actually be particularly challenging for mathematically highly capable and gifted students (Krutetskii, 1976). Because their thought processes are naturally very efficient (often combining two or more processes into one thought), breaking these processes down into sequential logical steps may require substantial effort, that they may initially be quite resistant to, and, therefore, may require intentional teacher support.
3. *Explore the mathematics further.* This is the stage that puts the onus of challenge, in part, onto students themselves to allow for even further meaningful differentiation. This is a stage that not all students in the class will reach, but once the problem is completed, understood and can be explained, the question to then ask is, "What's next?" Instead of the more capable students waiting to be given more work by the teacher, or being allowed to go on the computer to play, they were to be encouraged to ask this question for themselves, "What's next? What else can I explore within this task, to be creative, to challenge myself?" This was to be modelled by the teacher initially, but with the understanding that students would ultimately take on this role for themselves. The suggestion was that a chart could be drawn up and added to as new ways of exploring the mathematics were discovered (see Figure 4).

Fred's teacher implemented these strategies as a whole-class approach to teaching mathematics for a period of 12 weeks. Further classroom observations and follow-up interviews were conducted with Fred and his teacher after this intervention period.

Explore the mathematics further **some examples:**
• Can I solve this problem a different way? • Can I find another solution (for an open-ended task); how many different solutions are there, and how will I know I've found them all? • What if I try the same problem but make it more complicated (e.g., larger quantities, fractions, more components)? • How can I adapt the rules of this game to improve it? • What is the best strategy to use to ensure the greatest chance of winning this game? • What other components of this investigation look interesting, are worth exploring? (Permission to use computer search engines for investigations may be part of this).

Figure 4. Suggestions for exploring the mathematics further

Findings and Discussion

The findings from this case-study are derived from a qualitative analysis of pre- and post-intervention interviews with both Fred and his teacher, and pre- and post-intervention classroom observations. It is an analytical narrative of Fred's experiences. Analytical narrative gathers events and happenings as its data and uses narrative procedures to produce storied accounts (Polkinghorne, 1995). It is a synthesising of the data rather than a separation of it into its constituent parts, reducing the risk of detracting from the meaning of the whole as can happen when coding raw data into themes as a reductionist method of analysis (Lichtman, 2010).

Pre-Intervention

Prior to the intervention Fred's teacher mentioned that he,

> …always likes to get the correct answer, and he likes to know the explicit details of the task. So if I give him an open-ended maths problem, with limited direction at the beginning, he tends to ask lots of questions. He tends to ask for reassurance each step of the way, so he tends to say, 'Is this what you want?', 'Have I done enough?', 'Is this the right way?', so those sorts of questions. He tends to not like my response when I say 'Well what do you think?' 'How can you prove that this is the correct answer?', 'How else could you have solved it?' He likes to have one way, which is usually a standard algorithm he's been taught.

The school was developing a strong emphasis on inquiry-based approaches to teaching and learning and were working through the authorisation process for an International Baccalaureate Primary Years Programme (PYP). The PYP "focuses on the development of the whole child as an inquirer, both within and beyond the classroom." (International Baccalaureate, nd). Inquiry-based learning, then – including taking responsibility for your own learning, asking questions, looking for answers and collating that information – had been a major focus of Fred's class in the six months prior to the intervention for this study. It was also something that Fred really struggled with. According to his teacher:

> "It made [him] feel quite insecure, and I believe in the first unit of inquiry, and the second, he probably didn't perform at a level that I thought he was going to."

He also got quite distressed with any form of assessment:

> "[With] the *AIM* online [mathematics] assessment…we had tears because he didn't finish it quickly…it wasn't really about the maths, but because he was used to finishing

> [assessments] quickly." (The teacher had set him on a Grade 6 level test to challenge him, and the test is designed to get harder as they get answers correct.)
>
> "He got, again, quite stressed with *NAPLAN* [the Australian *National Assessment Program for Literacy and Numeracy*]. He really focused on the fact that there were two questions…he couldn't work out."

In talking with me Fred admitted that he 'knew he was good at maths' because he was:

> "Getting good grades. Also because when we're doing tasks I can understand it very quickly and some people have trouble to understand and I can like do problems really quickly."

He thought that Tony (in his class) was better than he was at some things because "He's just faster at it," although he concluded by saying "…we never really know who is better because we always get A pluses." He also stated that if given the option "like in a test or something, I'd definitely [choose] the easiest, because then I could get it done fast."

It became apparent with this information from and about Fred that 'catering for his mathematics learning needs' would require more than simply providing more challenging tasks. Teacher support would be necessary as he transitioned from the view of someone who is good at mathematics being someone who 'works fast' and 'gets A pluses' to a view of successful mathematics learners being those who persevere, who can generalise concepts, who extend mathematical ideas, who think creatively in order to overcome difficulties, and who are inventive in solving problems (Krutetskii, 1976). To provide this support Fred's teacher instigated several things. She:

- Used more open-ended tasks and focused on discussions around those tasks that highlighted the fact that she valued different ideas and approaches just as much as getting a correct solution.
- Used more partner work to generate mathematical dialogue.
- Provided direction through explaining the mathematical focus for the lesson rather than just giving instructions for the task.
- Was intentionally more consistent in the way she gave students feedback. Used more rubrics, including criteria such as "how they justified why they were doing what they were doing."
- Became more aware of how she questioned Fred. "I've become more aware of if I'm setting a task that's pitched at the whole year level, how I can make it a bit harder, and not being really explicit about that, just posing 'Well, could you try this?' or 'How could you change it?', or 'How could you teach someone else to do it that knew nothing about it?'

Post-Intervention

The Fred I observed in the post-intervention mathematics lessons was becoming more willing to think beyond the set task, to be more adventurous and creative. In a task where students were given a worksheet on "Financial Plans and Records" and were required to complete a two-month budget for a proposed after-school rubbish bin collection business, using the example on the worksheet as a guide, Fred and his partner decided they may be able to increase their profit margin in the second month through advertising. This required more expenditure (photocopying a flyer), but they decided it was a worthwhile expense that could generate more business and therefore more income. In discussing this with his partner Fred still seemed a little reticent initially, still a bit anxious about 'doing it right', but did not feel the need to check with the teacher before going ahead with their idea. In sharing their final results, others at the table were indignant when Fred announced that they had made a bigger profit the second month by spending extra on advertising and drumming up more business. James said, "I didn't know you were allowed to do that!" Connor said, "I thought we just had to follow this!" (pointing to the example on the worksheet). Fred's reply was, "Well it's not an *exact* question, it's an… *anything* question." The task was not specifically presented as an 'open task', but Fred and his partner were happy to think outside and beyond the set problem. This was in contrast to the Fred who previously needed to "know the explicit details of the task" and who constantly asked the teacher, "Is this what you want?", "Is this the right way?" before committing himself to the task.

In terms of explaining mathematical solutions his teacher said that she was:

> "…more aware to allow time to discuss what we've been doing at the end [of an open task]. So what new discoveries have you made? What challenges you? What area do you think you could continue to work on?... What did this task show you about your mathematical understanding?... I think that's helped [Fred] in being able to express his mathematical thinking to others, but also to be able to put it into writing."

> "I often say to him, 'If you had to explain this to someone who knew nothing about this, how would you tell them what you're thinking?', and so getting him to really break that down. So that's been an area I think he has developed in."

Prior to the intervention his teacher said, "[Fred] struggles with the creative element of any maths task," but during the post-intervention interview she said that he particularly enjoyed being given the freedom to modify mathematics games, "building in extra things to make it really difficult, or make it an *un*fair game [in a unit on probability]." This was also observed in one of the classroom observations where Fred and a couple of his peers decided they didn't like the high chance component of a *Decimal Path* game, and came up with several variations to the game rules that provided for more strategising, and subsequently more mathematical thinking and reasoning.

> "[Fred] is more willing to do that [be creative], and he gets quite excited, but he likes working with a partner in doing that."

Overall, Fred's teacher described the changes she had seen as:

> "He's not asking as many times, 'Is this right?' 'Is this right?', that he's having a go and thinking about it and justifying his thinking."

> "I think he's had a good year [so far]. His parents are happy with how he's progressed."

Conclusions

In introducing the idea of allowing and expecting creativity and challenge within mathematics lessons, changes were observed in Fred over the intervention period by both his teacher and the researcher. Fred's teacher believed these changes were all positive. The changes came about following intentional choices that his teacher made, in her approaches to lesson design, the questions she asked, and her expectations of students within her class. Fred appeared to be becoming less stressed about doing things 'the right way' and more willing to explore mathematics tasks further. He seemed to find this intrinsically rewarding, even though (or maybe because) this meant some of the mathematics work became more challenging for him and took longer to complete.

Being a single case-study few generalisations can be made, however the results do generate further speculations. If encouraging and expecting creative thinking and questioning are built into mathematics experiences right from the very earliest days of formal schooling would students like Fred have the same issues with insecurities and stresses about 'getting it right' at the beginning of Grade 5? While we can't do much about grading within school reports and government mandated testing such as NAPLAN, would regular use of rich tasks for other mathematics assessments, with rubrics that intentionally include criteria of creativity, challenge and exploring further embedded in them, as well as everyday intentional feedback noticing and celebrating student effort, perseverance, imagination and innovation, change the culture of an education system that has previously mostly valued correct completion of timed mathematics assessments?

If mathematically highly capable and gifted students, who naturally think creatively, are given permission and time to explore their own curiosities, imagine the sorts of amazing ideas they could come up with before they even finish school.

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