Developing Mathematical Resilience Among Diverse Learners: Preliminary Progress and Problematics

John Griffith Moala
Massey University
<j.g.moala@massey.ac.nz>

Roberta Hunter
Massey University
<r.hunter@massey.ac.nz>

Research shows that developing students' resilience can rapidly raise student achievement in mathematics. Despite recognising its importance, teachers often do not have access to a repertoire of practices to develop resilient mathematics learners. The present study explores aspects of resilience among a cohort of students from three low socio-economic, high poverty, urban schools in New Zealand. Our exploration uncovers some aspects of the students' perceptions (about learning mathematics) that were favourable and/or problematic with respect to the development of resilience. Implications for furthering the development of resilient learners are discussed.

Mathematics teaching and learning practices in New Zealand classrooms have perpetuated social and cultural inequities with frequent use of ability grouping and procedural learning associated with a Eurocentric view of mathematics education. These inequities result in the over-representation of indigenous Māori and Pāsifika students in low-ability groups in mathematics (Anthony & Hunter, 2017). *Developing Mathematical Inquiry Communities* (DMIC) challenges the status quo of inequity by focusing on a transformative re-invention of pedagogical practices designed to support teachers' development of ambitious mathematics pedagogy (Kazemi, Franke, & Lampert, 2009) and culturally responsive teaching (Gay, 2010). Implemented mostly in schools that serve marginalised Māori and Pāsifika communities, DMIC comprises the use of teacher-designed culturally and socially meaningful tasks; instructional practices that support respectful social interactions; and the development of a range of key mathematical practices such as questioning, explaining, and justifying.

Additionally, DMIC seeks to cultivate resilient learners - students who view challenges and mistakes as learning opportunities; who take risks; and who believe that they can get better at mathematics with time and effort. This goal of developing resilient learners reflects a growing understanding among educators that persistence and resilience in the face of challenges is a primary determinant of student success in mathematics (Farrington et al., 2012; Moala 2015). Research shows that an effective way of enhancing core mathematical skills among students is to develop "non-cognitive" factors such as: students' value of a given subject, their belief in their ability to learn, and their persistence through difficulty (Yeager & Dweck, 2012). Over recent years, educators have recognised that developing these non-cognitive factors is not a diversion from content but rather a key element in understanding mathematical content.

However, despite recognising the importance of resilience, teachers often do not have access to a repertoire of practices to develop resilient learners particularly in mathematics (Johnston-Wilder & Lee, 2010; Yeager & Dweck, 2012). Johnston-Wilder and Lee (2010) claimed that resilience happens by accident where it happens at all. In other words, what we know about the development of resilient mathematics learners is currently lacking. A premise of our present study is that an important step in developing a resilient learner, is understanding the extent to which this learner is currently resilient. This understanding becomes the basis upon which instructional interventions can be designed to promote particular aspects of the learner's resilience. As such, the present study explores resilience among a cohort of students (n = 101) from three low socio-economic, high poverty, urban

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schools in New Zealand. More specifically, we analyse the students' responses to questions pertaining to learning mathematics in their classrooms. The overarching aim of our analysis is to uncover aspects of the students' perceptions (about learning mathematics) that may be favourable or problematic with respect to the development of resilience.

Background Literature

Yeager and Dweck (2012) defined resilience as behavioural or emotional responses to challenges that are positive and beneficial for development (e.g., searching for alternative strategies, having high self-expectations, putting forth greater effort, and setting goals). Conversely, negative responses to a challenge (e.g., feeling helpless, giving up, cheating, and having low expectations) are indicative of not being resilient. Johnston-Wilder and Lee (2010) posited that the resilience required for learning mathematics is of a particular nature as a consequence of various factors including: the type of teaching often used, the nature of mathematics itself, and pervasive beliefs about mathematical ability being fixed. Furthermore, Johnston-Wilder and Lee (2010) claim that students who have mathematical resilience: persevere in the face of challenging situations, have the confidence to communicate their understanding (or lack of thereof), collaborate with others, and will have a growth mindset as regards learning mathematics (i.e., mathematical intelligence is not fixed, but can be developed through effort).

Similarly, teachers who seek to build resilient mathematics learners will: promote collaboration over competition among students; emphasise critical thinking over speed, rote-memorisation and regurgitating of ideas; and support engagement in challenging problems even if it leads to struggle rather than providing tasks that are easy to solve. We note that DMIC espouses the aforementioned principles for developing resilient learners (Hunter, Hunter, Anthony, & McChesney, 2018).

While many factors can influence a learner's resilience, Yeager and Dweck (2012) argued that it is not only the presence of difficulties and challenges that determine a person's outcomes but also a person's perceptions of those difficulties and challenges. On the one hand, a *growth mindset* can have a dramatic positive effect on student achievement. On the other hand, a *fixed mindset* with respect to intelligence compromises resilience in mathematics learning, among both high-achieving and low-achieving students (Blackwell, Trzesniewski, & Dweck, 2007). Yeager and Dweck (2012) explained the effect of fixed and growth mindsets in terms of two "implicit theories" of intelligence: entity and incremental respectively:

> The entity theory world is about measuring your ability, and everything (challenging tasks, effort, setbacks) measures your ability. It is a world of threats and defences. The incremental [theory] world is about learning and growth, and everything is seen as being helpful to learn and grow. It is a world of opportunities to improve. More precisely, an incremental versus entity theory shapes: students' *goals* (whether they are eager to learn or instead care mostly about looking smart and, perhaps even more important, not looking dumb); their *beliefs about effort* (whether effort is a key to success and growth or whether it is a signal that they lack natural talent); and their *learning strategies* in the face of setbacks (whether they work harder or whether they give up, consider cheating, and/or become defensive) (p. 304).

Blackwell et al. (2007) studied the transition of students from 6th to 7th grade (primary to intermediate) of minority students (n = 91) in a public school in New York, with a focus on the impact of resilience enhancement on their mathematics achievement. Most students in the study were identified as low-achieving students. The students were divided into two groups, with each group receiving a set of workshops. The control group's workshops focused on basic study skills, whereas the intervention group's workshops focused on growth mindset behaviours and how to apply these behaviours to their schoolwork. The study concluded that students in the control group showed continued decline in their mathematics achievement whereas the students that were exposed to the growth mindset workshops showed a swift increase in their mathematics achievement.

Methods

The data analysed for the present study comes from a larger study that focused on the implementation of DMIC and student and teacher perspectives with respect to mathematics teaching and learning. The participants (n = 101), whose data are analysed in this paper, were from three low socio-economic (decile 1) high poverty, urban schools in New Zealand, with a predominantly Māori and Pāsifika student population. The participants were from Years 5 to 8 (aged 9 to 12).

To explore the students' perspectives, both a written questionnaire and interviews were undertaken. In this paper, we focus only on data gathered from the student interviews. The interviews were conducted with pairs of students. Two sets of interviews (with the same set of questions) were conducted, one near the beginning of the school year and one near the end of the school year. The interview questions focused on their classroom experiences of learning mathematics both in the past and present, their dispositions toward mathematics, perceptions of how they learned mathematics or succeeded in mathematics, the teachers' role within mathematics lessons, and their perceptions of participating in mathematical practices in the classroom. The interviews were audio-recorded and wholly transcribed.

The results reported in this paper are drawn from the second interview (at the end of the year), specifically from students' responses to the following questions: (1) What do you do when you get stuck? (2) How do you feel about asking questions? (3) What parts of maths do you not like? (4) What makes someone good at maths? (5) What do you do to get better at maths? Table 1 below contains the questions that we focused on in this present study, with brief explanations for how these questions relate to resilience.

Table 1
Interview Questions

Questions	Reason for asking (with regard to resilience)
What do you do when you get stuck?	To explore how students respond to setbacks and challenges.
What makes someone good at maths?	To explore what students think a good maths student does.
What makes someone better at maths?	To explore how students feel toward the idea of improving their maths.
What parts of maths do you not like?	To explore experiences in maths that students do not like, and how students deal with them.
How do you feel about asking questions?	Given that *asking questions* featured in many of the responses to the four questions above, we decided to examine students' views regarding questioning.

Employing a grounded theory approach to data analysis, we developed a coding scheme to examine the data in light of our research aim. More specifically, we employed Auerbach and Silverstein's (2003) six-stage process model for analysing data from a grounded theory perspective: (1) reading raw text (i.e., interview transcripts); (2) identifying relevant parts of raw text; (3) identifying repeating ideas; (4) identifying themes among repeating ideas; (5) identifying relationships between different themes; and (6) constructing narratives which articulate relationships between themes. A research team (the authors plus four other researchers) met regularly to identify and discuss emerging themes. To ensure reliability of the coding and the results, four members of the research team coded each of the interview data independently and then met together to discuss and resolve discrepancies.

Results and Discussion

Table 2 below contains a summary of the students' responses to the interview questions (in Table 1). Three main themes emerged from our analysis of the students' responses to the interview questions. We report and discuss these three themes in this section.

Table 2
Summary of Students' Responses to Interview Questions

Question	Response Category/Code	Student %
What do you do when you get stuck?	Ask friends or group for help	51
	Ask teacher for help	38
	Re-read, try a different way, keep trying	3
	No response	8
What parts of maths do you not like?	Classroom climate (e.g., noise, distractions)	39
	Practices (e.g., explaining, sharing, justifying)	28
	Content	18
	Individualised work	6
	Nothing	6
	Getting the answer wrong	3
What makes someone good at maths?	Mathematical norms (e.g., taking risks, justifying)	39
	Collaborative norms (e.g., sharing ideas, questioning)	33
	Listening	24
	Getting correct answers	4
What do you do to get better at maths?	Work hard; Try hard and Take risks	37
	Listen for understanding	27
	Ask questions	18
	Practice	18
How do you feel about asking questions?	Negative emotional response (e.g., embarrassed)	38
	Positive emotional response (e.g., confident)	20
	Student explains how s/he questions	12
	Questioning develops understanding	12
	It is a collaborative norm	6
	Used to enquire about other's reasoning	6
	Learn new things (e.g., learning other's strategy)	6

On What Students Do When They Get Stuck

The results presented in Table 2 above suggest that when stuck, a large majority of the participants (89%) tend to ask someone (either someone in their group or the teacher) for help. For example: "*We ask someone beside us or someone who knows for help and they'll explain it in a way that we'll understand*"; "*I just would talk to our group first and if they don't know then I will ask the teacher and see if she can tell me*"; "*We ask our buddies, all of them, but if they don't know then we ask the teacher*". On the one hand, we note that asking for help is indicative of resilience because students are in fact acknowledging that they need help and that there is something that they do not understand. Indeed, asking for help is better than staying quiet and not doing anything about it, which a few students alluded to – their reason being that asking for help might indicate that they are not "smart enough" or "feel embarrassed" (Ryan & Pintrich, 1997).

On the other hand, we note potential problems with the act of asking for help. For instance, although students said that they would ask for help when they are stuck, the majority of students were not specific or explicit about what asking for help would involve. For example, consider the response: "*We would talk to our group first and if they don't know then we'll ask the teacher and see if she can tell us*". Presumably, there is something that the student does not know, but would like to know. However, it is not clear from this response, what this *something* is. Is it what the question requires one to do? Is it the answer to the question? Is it a clue about potential strategies to use? The extent to which asking for help is conducive to the development of resilience is likely to differ depending on what it is the student would like to know/help with (Mason, 2015; Ryan & Pintrich, 1997).

The lack of specificity in these students' responses might be ascribed to the lack of follow-up questions by the interviewer (which was apparent in some of the interview transcripts). However, it might also suggest that some students need explicit instruction on how to be more specific when seeking help. Past research has shown that being aware and specific about what it is that one does not know, the cause of one's *stuckness* (Moala, 2015) is in itself a learning achievement (Mason, 2015). Additionally, *goal-setting theory* (Meacham, 2004) argues that when stuck, precise and well-defined goals (e.g., coming up with a different strategy to solve the problem at hand) result in higher consistency of performance levels, than ambiguous goals (e.g., solving the problem at hand). This is not to say that such ambiguous goals are easy to attain, but the particularity of a goal provides a firm framework within which to evaluate one's personal performance (Meacham, 2004). An individual whose goals are elaborate and narrowly-focused will have more specific expectations for how they should behave/perform, enabling more effective and efficient modification of efforts to achieve these goals (Locke & Latham, 1990; Schoenfeld, 2012).

Furthermore, while the majority of students said that they will ask for help when they get stuck, 38% students had negative emotional responses toward asking questions. These students' responses included: "*For us, some people are scared because they feel embarrassed like they don't know*"; "*A little bit nervous 'cause I'm just too shy to asking [sic] questions sometimes*"; "*No I don't even ask a question 'cause sometimes if you're stuck and you don't know, the teachers growl you off cause they say you're holding up time*". Such negative emotional responses are problematic, because if students' first reaction to being stuck is to ask for help, then students should be confident and comfortable with respect to asking questions.

On Being Good and Getting Better at Mathematics

The majority of responses (96%) to "What makes someone good at maths?" indicate that students' perceptions of a good mathematics student align with achieving competence in practices that DMIC has sought to develop among students (e.g., questioning, risk taking, listening, explaining, and justifying). For example: "*Someone who can ask questions and explain their problems*"; "*Taking risks and explaining your strategies*"; and "*Someone who's not afraid to make mistakes, confidence*". Only four students reported that a good maths student was someone who knows the correct answers — a view which DMIC constantly and deliberately attempts to devalue.

Also aligned with developing resilience were the students' responses to the question: "What do you do to get better at maths?" All students' responses to this question seem indicative of a growth mindset (which is, as previously explained, fundamental to developing resilience). That is, students perceive "getting better at maths" as something that can be developed over time, through a variety of ways (e.g., practicing, questioning, taking risks; and listening). Some exemplary responses to this question were: "*My one's just listening, straight up listening I just need to try and listen*"; "*Listen and listen to other people doing their strategy so I can use their strategy to help with my learning*;" "*I need to ask for help and find someone that's really good at maths and someone that can support me through my maths*"; "*Push myself like take a risk and give it what I've got*"; "*Practice and ask your parents to make a chart of like many math questions, and like make a test and make your parents test you each day before you go to school and say to your parents to mark down as many questions you get right*".

While the above responses seem indicative of resilient students, we take a critical view of them when analysing these responses in conjunction with responses to other questions. Firstly, though the majority of students recognise that *being good at maths* entails being good at explaining, sharing, and justifying (mathematical and collaborative norms), 28% of students reported that the parts of maths they do not like included, explaining, justifying and other mathematical/collaborative practices. For instance, students' responses included: "*the explaining and sharing part cause sometimes I get asked questions and I don't really know the answer to that and its hard*"; "*Sometimes when people disagree with you and you got a different answe*r". Furthermore, the fact that 38% students express negative emotions with regard to asking questions problematises the fact that many students identified asking questions as an important part of not only being good at mathematics, but also getting better at mathematics. It seems that although students might have perceptions of what being good/getting better at maths entails (e.g., asking questions) which align with resilient behaviours, students might not necessarily be as favourable towards enacting these perceived necessary actions (e.g., too embarrassed to ask questions).

On the Parts of Mathematics That Students Do Not Like

In response to the question of "What parts of maths don't you like?" the majority of students alluded to the classroom climate and development of appropriate norms. These included aspects such as appropriate group work behaviour, noise level, organisation of tables, and the availability of pens. Responses pertaining to classroom climate included: "*Sometimes you get annoyed 'cause they won't do anything until you do it*"; "*When people don't focus and don't share the pen*"; "*My least favourite part of maths is when I'm trying to explain to someone and that person doesn't listen and their talking about something else*". While the issues of classroom climate are perhaps not directly related to resilience, they can pose unnecessary challenges to students' learning and the development of resilience (Johnston-Wilder, 2010).

A reasonable portion of students (28%) reported that they did not like things that are hard, and 18% students reported that they did not like a specific topic (e.g., fractions, decimals) due to difficulty. Some representative responses were: *"I don't like answering and sharing my ideas 'cause its hard*"; "*When it's hard and I don't know the answers"; "I don't* *like decimals, it's hard, I don't want to do them"; "Number trees 'cause it's hard and we have to really think"; "I don't like fractions, I find them hard"; "Asking questions and saying what the reason is…kind of hard."*; *"The explaining and sharing part cause sometimes I get asked questions and I don't really know the answer to that and it's hard and also I don't like decimals either".*

Students' dislike (and, at times, avoidance) of hard content or difficult situations may be problematic with respect to the development of resilience, simply because resilience is unlikely to develop without engaging in difficult situations and grappling with hard content (Mason, 2015; Moala, 2015). Research shows that differences in task performance between individuals with similar levels of achievement can be attributed to differences in motivation (Meacham, 2004). Goal-setting theory posits that the motivation to perform at a high level is directly proportional to the level of difficulty of one's goals and experiences, because difficult goals lead to greater effort, persistence, and more controlled attention than easy goals. The motivation to perform at a high level (high expectations) is a critical aspect of resilience (Johnston-Wilder & Lee, 2010; Yeager & Dweck, 2012) and the extent to which this motivation is developed is directly related to the level of difficulty of one's goals. Furthermore, mathematicians have long supported the role of struggle, which can only result from engaging with difficult mathematical problems. This view is captured nicely by Polya (1945):

> Teaching to solve problems is an education of the will. Solving problems, which are not too easy for him [sic], the student learns to persevere through unsuccess, to appreciate small advances, to wait for an essential idea, to concentrate with all his [sic] might when it appears. If the student had no opportunity in school to familiarize himself [sic] with the varying emotions of the struggle for the solution, his [sic] mathematical education failed in the most vital point (p. 93).

Concluding Remarks

Motivated by the lack of knowledge about the development of resilient learners in mathematics, the present exploratory study examined the resilience of a cohort of students (n = 101) from three low socio-economic, high poverty, urban schools in New Zealand. More specifically, we analysed the students' responses to questions pertaining to learning mathematics in their classrooms. Our analysis uncovered some aspects of the students' perceptions (about learning mathematics) that were favourable and/or problematic with respect to the development of resilience. Based on our analysis, we highlight two primary suggestions for the further development of resilient learners: (1) learners should expect mathematics to be difficult (more often than not). They must embrace the challenge, and be comfortable within the state of not-knowing; and (2) learners need explicit instruction on how to be more specific with help-seeking when stuck (e.g., set specific, rather than broad, goals to be accomplished).

One particular limitation of our findings, and consequently the aforementioned suggestions, stems from the fact that our data were students' perceptions about learning and doing mathematics, as opposed to learning mathematics and doing mathematics in the moment. These perceptions/beliefs, of course, are *implicit theories* (Yeager & Dweck, 2012) that influence students' performance/activity. However, such perceptions do not necessarily align with students' actions in the moment. Students who say they will ask for help when stuck, will not necessarily ask for help when they do get stuck. Students who say that they are shy to ask questions or explain their thinking, might not necessarily be shy to do so in the moment. Overall, while students may identify what resilient behaviour comprises, students might not necessarily exhibit these behaviours when necessary. As such, one direction for future research is to analyse these students' in-the-moment actions while working on tasks that are challenging and require resilient behaviours.

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