Developing positive mathematics learner identities in secondary school

School resources

'I just don't have a maths brain' or 'I'm more of a creative person' are frequently heard phrases from adults and students alike. These comments speak to the individual's relationship with mathematics or their sense of self as a learner of mathematics – that is, their mathematics learner identity. For teachers, these sorts of comments raise alarm bells as they are often accompanied by students disengaging from mathematics learning before they even give it a chance, or perhaps a promising student dropping mathematics without fulfilling their potential.

Mathematics is a gatekeeping subject[1], meaning it is a subject required for many different career and tertiary pathways, in addition to being essential for everyday life. Therefore, those students who opt out of mathematics due to their mathematics learner identity reduce their options. Yet mathematics learner identity is not fixed, and this means that teachers can do something about it. In fact, a mathematics learner identity says as much about the type of mathematics an individual has experienced throughout their life as it does about that individual. This means teachers and leaders can take a close look at mathematics teaching and consider the sorts of mathematics learner identities it promotes for students. This review will share what the research says on the concept of mathematics learner identity, then present a model of mathematics teaching developed with the promotion of positive learner identities in mind.

What is mathematics learner identity?

It can be difficult to fully understand the concept of mathematics learner identity as it is somewhat abstract. According to the encyclopaedia of mathematics education, it is 'a socially produced way of being, as enacted and recognised in relation to learning mathematics'[2] and it interacts with multiple other identities. This means that someone's mathematics identity must be understood in context, and it may be different depending on context (in the classroom, at home, in the workplace, or with friends). Someone's mathematics learner identity might be understood by the way they act or talk about mathematics, but also by the way other people treat them; in other words, when we put someone in the 'top stream' or label someone as a 'merit' student, we contribute to their developing mathematics learner identity. Finally, because we have multiple identities in terms of, for example, ethnicity, culture, gender, linguistic identity, or neurodiversity, it may sometimes be difficult to cohere being a mathematics learner with those other identities.

Research has found identity to be a very useful concept for explaining students' participation or engagement in mathematics and why some social groups are marginalised within mathematics education. It may also help us to understand how different experiences of mathematics learning impact on the relationships students form with mathematics in nuanced ways. An individual's mathematics learner identity helps to explain why they choose to continue, or alternatively, disengage from or discontinue, studying mathematics.

A range of research has explored mathematics learner identity to understand the different choices students make about further mathematics or their level of engagement in their current mathematics class. For example, one UK study of post-compulsory mathematics students found that mathematics learner identity was a factor in future career aspirations[3]. Another found that students opted out of maths

because they perceived maths to be difficult or boring, they lacked confidence, or they failed to see the relevance of maths[4]. By contrast, other studies found that students saw challenge and opportunity in the transition to post-compulsory mathematics[5], and that boredom, dislike, or anxiety about mathematics were variable depending on the context[6]. Such studies on mathematics learner identity help to explain why some promising students lose interest in mathematics, and also why other students might make different choices about mathematics despite seeming to have similar experiences.

Participation in mathematics is influenced by other social identities as well as mathematics learner identity. When considering students' other identities, such as their gender, ethnicity, culture, social class, or neurodiversity, and how these intersect with mathematics learner identity, it is possible to see how mathematics learning experiences may exclude some groups of learners. For example, mathematics is often considered to be a masculine subject, making it more difficult for girls to identify as 'good at maths'[7]. Other research discusses the racialised nature of school mathematics, raising the question of who is likely to be considered mathematically literate and who is not, and identifies a racial hierarchy in which Black students are positioned at the bottom[8]. Mathematics has also been seen as a colonising force, excluding Indigenous or other marginalised identities. In Aotearoa New Zealand, this tends to restrict Māori[9] or Pacific peoples[10] from full and equal participation. By contrast, if students see their own culture represented in the mathematics content, context, or practices[11], they are more likely able to develop positive mathematics learner identities and a sense of belonging in the mathematics classroom[12].

Students identified as having learning differences are often excluded from meaningful learning of mathematics through being withdrawn from the classroom or not given mathematics that involves the higher-level problem-solving activities[13]. The research on the intersection of mathematics learner identity with neurodiversity is currently underdeveloped[14], but it is an area ripe for exploration. In short, some students find it easier to align their gender, cultural, ethnic, class, and other identities with mathematics learning, while others may find it difficult to cohere the type of person they are expected to be in the mathematics classroom with their social identities.

Identity research also goes beyond the classroom to look at out-of-school experiences and the involvement of parents. For example, identity is implicated in homework practices such as students' personal motivation or their uptake of resources such as parental help[15]. Parent help is itself influenced by the parent's (or typically the mother's) own mathematics identity and their knowledge and valuing of new methods for mathematics learning[16]. In turn, the student's identity may be affected by whether or not the school values home mathematics, especially pertinent in immigrant families[17].

Identity research highlights differences in the type of mathematics experiences students receive and the potential impact of these differences on their mathematics learner identity. For example, the influence of peers in the mathematics classroom[18] and pedagogical decisions such as using cooperative groups[19] both affect mathematics learner identity. Streaming, or so-called 'ability' grouping, is an issue particularly pertinent in Aotearoa New Zealand, from primary school[20] through to secondary[21]. International research has identified the damage that ability grouping may do to students, particularly streamed into the middle and lower 'ability' levels but sometimes those in the top stream too[22]. The following two quotes from secondary students show how the same act of putting a student into a high ability group implicates identity differently depending on their experiences in those groups:

I think a highlight for me was being included in the 'maths plus' group at my intermediate school. This was a group for students across the school who were showing an above-average interest or ability in maths. This group would take place every year with Mr X and was one of my highlights from schooling in general. The teacher made the learning fun and I learnt heaps more than in class. This is because the

teacher himself was extremely passionate about the subject and [went on] side tangents such as the fibonacci sequence or logic puzzles and murder mysteries. This meant that every maths plus class would be something new and different and I looked forward to it every time. (Year 12 mathematics student, male, Auckland)

The lowest point of learning mathematics was when I [was] put in a higher-level maths group and they would all know how to do the work and I would have no clue. Feeling like you're not smart in class compared to others is a very demotivating thing and can take the fun out of learning a subject (Year 12 statistics student, female, Northland)[23]

The kinds of mathematics learning experiences offered to different streams can provide different opportunities to develop a sense of ownership of the mathematics learning[24]. Further, grouping by so-called ability is influenced by other social identities such as class[25], gender[26], and race[27]. Indeed, the very notion of 'ability' may be conflated with access to educational opportunities[28] and thus streaming potentially exacerbates those differences in opportunity.

The relevance of mathematics learner identity in the classroom

While mathematics learner identity greatly influences an individual's learning of mathematics, crucially the above quotes show how the nature of the mathematics learning experience also influences mathematics learner identity. The mathematics teacher, therefore, plays an important role in designing learning experiences that may foster positive relationships with mathematics, although there are a variety of different mathematics learning experiences that build mathematics learner identity in differing ways. This is illustrated by a model for mathematics teaching called *Multifaceted Mathematics*[29]. *Multifaceted Mathematics* acknowledges the diversity of findings on 'good mathematics instruction' and the varied purposes of different kinds of learning experiences. The model delineates four facets that are named Creating, Applying, Learning, and Practising. Each facet is a common form of mathematics learning at secondary school. Both the Creating and Applying facets stem from research that is sometimes called 'reform mathematics'[30], which is all about having students engage with investigations, proof, or problem-solving, usually in mixed-ability, collaborative groups and ideally using authentic contexts where possible. The facets of Learning and Practising acknowledge that students do not learn by osmosis, and they sometimes need more explicit instruction followed by opportunities to practise that new learning for retention.

The facet of Creating is the most closely related to what a mathematician does. It is about engaging with investigations in any strand of mathematics, and it might involve making generalisations or conjectures that can be proved or disproved, or model-eliciting activities (for example, creating criteria to judge a freehand circle drawing competition). Often this kind of mathematics learning experience demands creative thinking in coming up with those generalisations and conjectures. In terms of mathematics learner identity, the Creating mathematics facet emphasises the beauty and joy of mathematics and gives students the message that **mathematics can be a creative endeavour**. To use an analogy: despite it being important to learn how to kick a ball, or to practise musical scales, a footballer or a musician is made through playing[31].

On the other hand, the Applying facet refers to the kind of problem-solving that is closely related to real life. Here is where authentic contexts come into play. Ideally the contexts would be highly relevant to the specific students in the class, that is, related to their home community or cultural backgrounds, so that they may begin to appreciate mathematics as something that is useful for real life. Conducting statistical investigations with students' own data is one accessible way to do this, and mathematics related to community events is another, such as exploring mathematics related to Matariki. Explicitly

linking cultural knowledge to mathematics curricula knowledge helps to develop mathematics learner identity[32]. The Applying mathematics facet might well eliminate the common question 'when am I ever going to use this?' that we sometimes hear from students. This facet delivers the important messages that **mathematics is useful and relevant** to the lives of our students.

Of course, students need the opportunity to learn new mathematics content before they can apply it to a problem context. In contrast to the emphasis on 'reform mathematics', there is also a body of research that emphasises the importance of explicit instruction[33]. A mathematics programme that only involves problem-solving without also allowing for instruction of key ideas, knowledge, and techniques is very likely to leave some students behind. While new learning may occur during investigations and problem-solving, sometimes it requires more deliberate teaching. Here students' mathematics learner identities are developed as they gain a sense they are progressing in mathematics and adding to their personal knowledge base. Whilst this facet may seem obvious, there are groups in the mathematics class who are marginalised through their not having the same **opportunities to learn powerful mathematical ideas**. This is sometimes due to low expectations (of Māori students, for example[34]), or positioning students as incapable due to neurodiversity or disability[35].

Students need to retain their recently learned skills and knowledge (as opposed to skills and knowledge learned a long time ago). Sometimes their engagement in problem-solving or investigations will do this, other times it is useful to do 'exercises'. Students' build their mathematics learner identity through this facet of Practising when they **develop confidence and fluency through consolidation of new learning**. Mathematics learner identity is particularly promoted when the students have agency over what they get to practise – often they know what they need to work on, and they may develop a more agentic relationship with mathematics learning if they have the element of choice.

Positive mathematics learner identities for all students

Secondary school mathematics should contain each of the different facets of mathematics learning experiences, but it is important to consider whether all students experience each of them. Sometimes higher achievers do not get many opportunities to learn new maths, and lower achievers do not get many opportunities to do the fun, creative, problem-solving facets of maths. In each case, this may impact on their mathematics learner identities. Developing positive relationships with mathematics is important because a positive relationship will help to ensure students' continued participation and eventual future success in the subject[36]. While the research shows that mathematics learner identity is an individual construct and that there are many other factors at play, the teacher can certainly organise the classroom to promote mathematics learner identities as much as possible.

Experiences with mathematics investigations and proofs give students the message that mathematics is fun and creative. Opportunities to apply mathematics in authentic problem-solving contexts teach students that mathematics is relevant and useful in their own lives. Learning new mathematics gives students a sense of progression in the subject and practising their learning builds fluency and confidence. It is no co-incidence that this approach describes aspects of effective instruction: developing positive identities in students can be done hand in hand with good teaching. In short, students need to see that mathematics is fun and useful, to make progress, and to feel confident in order to develop positive mathematics learner identities.

Endnotes

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