A Story of a Student Fulfilling a Role in the Mathematics Classroom

Naomi Ingram
University of Otago
<ningram@maths.otago.ac.nz>

This paper presents a case study of a secondary school mathematics student in New Zealand. Stories about this student relating to the context of mathematics form his mathematical identities and are told by his parents, his teachers, his peers, himself, and the researcher. The student's negative affective responses to mathematics are explored through these stories. The student was found to have very positive beliefs, values, attitudes, feelings, and emotions about mathematics. He "loves" mathematics because of his enjoyment of mathematics as a discipline, and because he is good at it compared with his classmates. He is perceived to be in the top group of mathematicians in his school, a role endorsed by himself, the school, his teachers, and his peers. During the year however, he becomes less positive about some aspects of mathematics as he struggles to continue to fulfil this role.

Introduction

Exposure to mathematics seems to generate a range of emotions and feelings in secondary school students. These affective responses are often negative and are thought to influence both learning and achievement (Gómez-Chacón, 2000; McLeod, 1992; Reyes, 1984). Students seem to become less resilient to negative emotions and feelings about mathematics as they move through school (McLeod, 1992), and it is important to capture this process of change by conducting research in mathematics classrooms over a period of time to understand its effect on the students' learning of mathematics (Leder & Grootenboer, 2005).

This paper presents a case study of one secondary school student and forms part of a continuing research project. This project investigates a group of students over two years to capture their mathematical identities (who they are in mathematics) and explore the students' negative affective responses to mathematics. The main data for the research are stories told by the teachers, the parents, peers, the researcher, and the students themselves.

In the next section, the theoretical background of the affective domain and the use of stories for investigating learning are outlined. The methodology is then detailed and the student described in terms of his mathematical identities and his negative affective responses to mathematics.

Theoretical frameworks

The Affective Domain

There have been varied definitions of the affective domain in the literature (Leder & Grootenboer, 2005). This research however uses Douglas McLeod's definition. McLeod (1992), a mathematics educator, described the affective domain as a "wide range of beliefs, feelings, and moods that are generally regarded as going beyond the domain of cognition" (p. 576). This domain had three components: beliefs, attitudes, and emotions. Further research enlarged McLeod's model to include values (Goldin, 2002), and an understanding of the relationships of different parts of the domain. Leder and Grootenboer (2005)

summarised the different conceptions and relationships in Figure 1. The different elements of the domain lie on a continuum of stability and intensity of responses, and levels of cognitive and affective involvement. This model of the affective domain is useful as a beginning framework to inform this research.

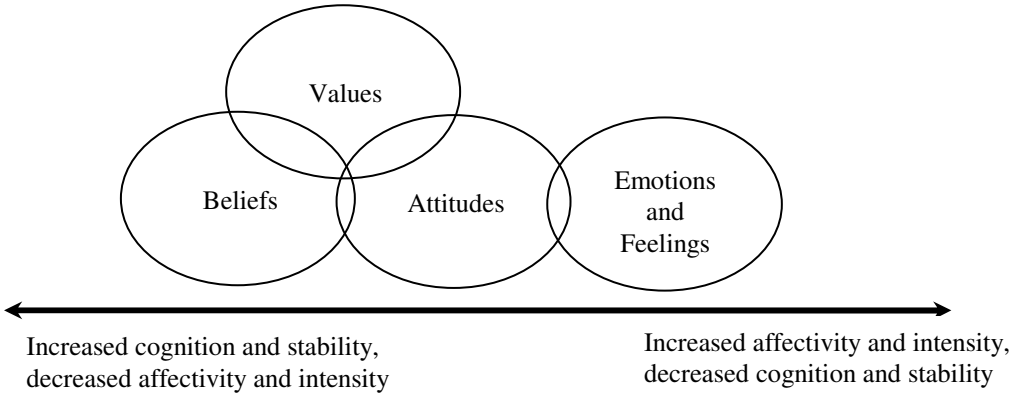

Figure 1. The affective domain (Leder & Grootenboer, 2005).

Rather than study just one of the elements of the affective domain, it is the relationships among the elements that are significant in understanding the effects on learning (Schuck & Grootenboer, 2004). Emotional responses, for example, may result from a perceived conflict with beliefs (McLeod, 1994), and when a person repeatedly experiences an emotion, this may lead to more stable attitudes and beliefs (Zan et al., 2006). For the purposes of this paper therefore, an *affective response* is thought of as a reaction to mathematics that could relate to any part of the affective domain. This reaction could be for example, joy, anxiety, fear, avoidance, frustration, or boredom. Only negative affective responses are considered here, which are defined more operationally in the methodology section of this paper.

Mathematical Identities

As socio-cultural theories have become prominent and there is focus on understanding individuals' actions, there has been renewed interest in the notion of identity (Sfard & Prusak, 2005). Grootenboer et al. (2006) suggest *identity* is a connective construct containing multiple elements such as beliefs, attitudes, emotions, cognitive capacities, and life histories, defining it as "how individuals know and name themselves … and how an individual is recognised and looked upon by others" (Grootenboer et al., 2006, p. 612).

Anna Sfard and Anna Prusak believe identity to be a narrative "constantly created and recreated in interactions between people" (Sfard & Prusak, 2005, p. 15). They see identity as individuals' visions of their own and other's experiences. They "equate identities with stories about persons. No, no mistake here: We did not say that identities were finding their expression in stories – we said they were stories" (Sfard & Prusak, 2005, p. 14). More operationally, they define an identifying story to be:

- *Reifying* - through the use of the words *be, have, can, always, never, usually;*
- *Endorsable* - with the identity-builder (the person the story is about);
- *Significant* - if any change in it is likely to affect the storyteller's feelings about the identified person particularly with regard to membership of a community.

People therefore have a number of stories relating to them. They have multiple identities. Sfard and Prusak (2005) split these multiple identities into *actual identity* (*I am, he is* – stories about the actual state of affairs) and *designated identity* (*I should be* – a state of affairs expected to be the case now or in the future). In this paper, stories told about the student by the participants in the social context of the mathematics classroom are viewed as *mathematical identities.*

Methodology

Cresswell (2003) prescribes for research a methodological framework with three elements: "philosophical assumptions about what constitutes knowledge claims, general procedures of research called strategies of inquiry, and detailed procedures of data collection, analysis, and writing, called methods" (Cresswell, 2003, p. 3). In terms of knowledge claims, my research is guided by social constructivist principles. The data are filtered through my personal and cultural values and experiences that form my own identity and I need to acknowledge that filter. I am an experienced secondary school mathematics teacher with previous research interests in cooperative learning and therefore I am strongly influenced by social dimensions of learning. This research therefore is largely classroom based; it is important that I spend time with the students in their classroom environment to try and understand their processes of engagement and interaction because this is the major arena for developing mathematical identities.

Although theoretical perspectives on affect and identity help to inform my research, I am also informed by a grounded theory approach to the methodology and this approach is my strategy of inquiry. Grounded theory is the derivation of theory from data "systematically gathered and analysed through the research process" (Strauss, & Corbin, 1998, p. 12). This approach is useful for this investigation because it allows the research to be inductive. Decisions I make about each stage of the data collection process are grounded in the data itself and the emerging categories and themes (Strauss, & Corbin, 1998). Using each piece of data to learn more about each student, the class, and the context, I am better able to direct each phase of my data collection and analysis.

This is an instrumental case study in the sense that I am exploring in depth one individual and collecting rich data about that individual over a period of time (Cresswell, 2003). The case itself however, is of secondary interest to the purpose of the research, and the overall project is a analysis of multiple case studies to understand negative affective responses in mathematics (Stake, 2005).

Participants

The participants in the larger study are 30 students aged 14-15 who, in 2006, were in the same mathematics class in a co-educational, medium SES, urban secondary school in New Zealand. The students were chosen to be in the achievement class of their year level because they demonstrated excellence in one or more fields, not necessarily mathematics. The students' mathematical abilities range from average to high.

The participant chosen for this initial case study is Colin. He is of high ability according to standardised testing, and was chosen for this paper, rather ironically, because he demonstrates very few negative affective responses to mathematics. He is, indeed one of the most positive students I have come across. It makes the negative responses he does have significant in their rarity and because of this there is an element of clarity about them.

Data Collection and Analysis

Methodology in affective research needs to be broad enough to capture the complexity of the issue (McLeod, 1994; Zan et al., 2006), and therefore I am using a variety of instruments and techniques in the study. The expanding data set for the larger study consists of audio-taped and video-taped observations, interviews with students and teachers, student and parent auto-biographical questionnaires, an anxiety questionnaire (adapted from Chiu & Henry, 1990), metaphors collected from the students about mathematics (Buerk, 1996), students' drawings of mathematicians, assessments, exercise books, school reports, academic prizes, disciplinary reports, student subject choices (initial and actual), enrolment information, and student journal writing.

Each piece of data that pertains to Colin or his social and physical context is seen as a story and therefore identified according to Sfard and Prusak's (2005) operational definition of identity and represented by ${}_{B}A_{C}$ where A is the identified person, B is the author, and C is the recipient. This creates a structure to differentiate between multiple identities of an individual; for example, a story told about Colin by the teacher to the researcher would be ${}_{\text{Teacher}}\text{Colin}_{\text{Researcher}}$. I then took a subset of these identities and highlighted instances of when Colin displayed or experienced negative affective responses. Operationally, a negative affective response is seen as a negative reaction to mathematics that could be:

- Physiological – a physical reaction, such as going red, or becoming agitated;
- Psychological – feelings such as dislike, boredom, worry, panic, frustration;
- Behavioural – an overt and observable reaction to mathematics endorsed by the student, for example, poor classroom behaviour, avoidance of mathematics.

A microanalysis was performed on these stories to understand how Colin's negative affective responses position themselves within his mathematical identity.

Results

Describing Colin

Colin is a tall, angular boy who has the loose-limbed carelessness of a teenage boy, too big already at 14 for the school desks. Colin is the oldest child of two. His parents describe him as an imaginative, caring, and helpful boy with a good sense of humour, and a strong sense of justice. Colin, his teachers, and his peers endorse this view of his personality. He does well in all his subjects, in particular music, where he is viewed as gifted.

During the observational phase he always had with him the necessary mathematics books and equipment. His teachers describe him as well behaved, with sound work habits, and a positive manner. This was observed, in general, during the course of 2006, and Colin agrees he works hard in mathematics. Colin's squared exercise book shows that he completes the set work neatly on a ruled and dated page. There is little working shown when he is completing exercises from the textbook, the main activity in the class. His working on starter problems however, are written out of the squares in a larger, more fluid style.

Colin loves mathematics, thinks it is fun, and is excited by it. "Maths is a thing for me … I just feel like I have a thing for maths" (${}_{\text{Colin}}\text{Colin}_{\text{Researcher}}$). He concurs he loves it for two reasons; one because of his enjoyment of the field of mathematics itself, and the other because he perceives he is good at it compared with his classmates.

Colin the Mathematician

Colin's own definition of mathematics is that it is "a language we use to evaluate situations and predict what will happen next" ($_{Colin}$Colin$_{Researcher}$). His metaphors for mathematics are all scientifically oriented. He believes that mathematics is like

> 1. The universe. It is infinite and all encompassing. 2. An atom because it makes up everything. 3. The entire worldwide ecosystem. It fits together like a giant jigsaw puzzle. 4. The colour white. It is a blending of all the colours of light like all the elements of maths ($_{Colin}$Colin$_{Researcher}$).

Importantly, he believes mathematical learning to be of great value and not restricted to the curriculum or institutional structure.

> When stuff is really repetitive it motivates me to actually do my work … perhaps if I can get all of these done I can have some free time at the end of the period and think about music or other maths … I don't see maths as a subject itself, I think of it more as a thing that goes everywhere ($_{Colin}$Colin$_{Researcher}$).

Colin does not suffer from significant test anxiety. Colin, early in the research period, expressed only very mild, probably facilitative anxiety, when doing a mathematics test, and being given a mathematics test he was not told about. He also does not worry about getting tests back. Colin enjoys being challenged during mathematical activity, and is patient when he does not immediately understand something, knowing that he will in a few minutes, a few days, or a few years. The more he learns, the better he feels about it.

> There's no problem that I haven't found out the answer to … I have a big book at home full of brain teasers … and you learn how they work eventually and some I just don't get and I come back and I'm like oh I know what that word means now so … or I know the answer to that now. That makes sense ($_{Colin}$Colin$_{Researcher}$).

When asked to draw a mathematician, Colin drew a trendy man with dreadlocks and wrote:

> Say hello to Simon. He is *the* mathematician. He has cool sunglasses to prevent UV rays getting into his eyes and going into his brain. He is a normal person. He's really cool. In other words, anyone can be a super mathematician. So instead of drawing a stereotypical nerd, I drew my form teacher … [he] is actually [not] that great a mathematician, but hey ($_{Colin}$Colin$_{Researcher}$).

Refreshingly, Colin feels that there is little social stigma attached to being good at mathematics.

> No one really cares about whether you're a nerd or not any more … people are my friends regardless. It's great. I love it. I'm lucky to be born at this time … nerds don't really exist as much any more ($_{Colin}$Colin$_{Researcher}$).

Being Good at Mathematics

Colin enjoys mathematics because he perceives he is good at it compared with his classmates. "I always like being better … than other people … I like the feeling of knowing that no-one usually understands that but I kind of do"($_{Colin}$Colin$_{Researcher}$). He clearly acknowledges he is one of the top mathematicians in the class and indeed the school.

Colin, with Peter and Angela, are three students that recognise themselves and are recognised by others as being top in the class. "Everyone wants to be in my group when we do maths things … it's like [calling out] Peter, Colin, Angela, come over here" ($_{Colin}$Colin$_{Researcher}$). Colin's name was mentioned (unsolicited) by ten students a total of 18 times during interviews as being a part of this group or the top student in the class. Peter

and Angela were only mentioned a couple of times, and others in the class at the most once. One student, whose mathematics capability is similar to those in this group, identifies Colin and at the same time distances himself because of how he perceives his own behaviour. "I feel like there are … people like Colin and Angela that just get down to it. I probably don't feel like [I'm in the top group] because I just slack off when I can"($_{\text{Finlay}}$Colin$_{\text{Researcher}}$). Other students think Colin knows the mathematics automatically "If it's something hard, it takes a couple of weeks to get through my head … but the really brainy ones like Angela and Colin … it's just like they know it"($_{\text{Tia}}$Colin$_{\text{Researcher}}$).

Colin is especially competitive with Peter and Angela and they are observably competitive with him. Colin knows all of their results in mathematics for the last few years and thinks about their learning processes. "I do think about it more complicatedly than [Angela] does sometimes. She's a better learner and more motivated person than I am sometimes because she's a girl" ($_{\text{Colin}}$Colin$_{\text{Researcher}}$). Other people in the class do not feel competitive, and do not see that label as applying to them, only to people in the "top group", again identifying Colin as one of them."That's not like me. That's between Peter and Colin and people like them. I don't compare myself with them. They're a lot better than me at maths" ($_{\text{Fern}}$Colin$_{\text{Researcher}}$).

The main role Colin has in the class is that of unofficial teacher or tutor, a role he enjoys. "I like it when people ask me things. I could be a teacher when I grow up … and even when someone else might [be able to help] … I feel like they think I'm just the person who knows it really" ($_{\text{Colin}}$Colin$_{\text{Researcher}}$).

The School and the Teachers

In the three years before 2006, Years 7, 8, and 9, Colin received mathematics honours awards at prize-givings (only 2 or 3 are given per year). Colin himself endorsed these rewards as being important to him; he remembers what he and several of his classmates got in all their subjects over several years. He had, until the middle of Year 10 in 2006, received mostly Excellence grades or near 100% in his mathematics assessments. Colin's school reports reinforce his ability in mathematics to Colin and his family with strong identity statements. "Colin is an excellent student" ($_{\text{Year 7 Mathematics Teacher}}$ Colin $_{\text{Colin/Parents}}$). "Colin is brilliant. He has never really been tested this year in class, however he has stayed focussed and set his sights only on excellence. His exam results were impressive. He is certainly deserving of the [honours award]" ($_{\text{Year 9 Mathematics Teacher}}$ Colin $_{\text{Colin/Parents}}$).

Colin is always included in mathematics competition teams or external mathematics enrichment activities. Other students who have the potential to be in the top group of students but are not recognised as such, perceived themselves to be excluded from mathematics competitions and external projects only requiring two or three people, often because the teacher automatically asked those in the "top group" or had an expectation it is those people who go.

During the observational phase of this research, the teacher frequently named Colin to the class, to encourage others to get help off him, or to highlight his work or assessment results. He spoke openly to the researcher in front of the students about who was good at mathematics in the class. Colin frequently put his hand up to answer questions and was well received by the teacher, sometimes to the exclusion of others in the class. During one observation, the teacher asked a series of verbal questions to check students' understanding. Except for one other person, who was not asked to contribute, only two people put their hands up for the entire session, one of whom was Colin and the other Angela.

Negative Affective Responses

During 2006, some negative emotions and feelings could be observed in Colin. Early on in the research period, I asked him if he wanted any help with a difficult starter I had seen him struggling with after the class had gone on to the main lesson. Colin seemed immediately flustered and defensive and told me that was not the focus of the day's lesson. He seemed genuinely surprised that I asked. The teacher laughed when I told him about it and said Colin was not used to being asked if he wanted help. When I asked the class to hand in their exercise books that day, Colin did not want to and hid his book, as he did on another occasion when he had perceived he had done little work.

A number of times Colin reacted badly when he got marked assessments back and seemed defensive and secretive about his marks. He explained he got a bit down in class when he did not do well in an assessment (which he defined as achieving Excellence, 100% or performed comparatively to the others in the top group). This was highlighted during the interview when he was asked what his worst mathematics experience was.

> Whenever I only get one wrong. I feel like [I] can't get 100% in a test. I shouldn't be making silly mistakes. I check it like three times. I wish I could like start school again and then get 100% in every test … and then be able to say I got 100% in every test I ever did at school ($_{\text{Colin}}$Colin$_{\text{Researcher}}$).

During the year Colin had a moderate number of absences mostly due to music commitments and a noticeable change of focus. During one term, he had 13 absences out of 34 periods, missing around 40% of the lessons. In Colin's individual interview he said that he found it hard when he had missed out on work by being away and someone told him what to do when he would normally tell him or her what to do. "Then when I get it I am back on top" ($_{\text{Colin}}$Colin$_{\text{Researcher}}$). Different too from the beginning of the year he now said that he felt anxious in mathematics when he did not know something, and he perceived everyone one else knew how to do it.

In the latter part of 2006, Colin talked about his parents. "They … don't want to push me, but they end up pushing me because I've got Excellences all the time and they get a bit worried when I don't get an Excellence, I just get a Merit" ($_{\text{Colin}}$Colin$_{\text{Researcher}}$). Colin's mother was already aware his level of focus had changed. "His interest in maths extension opportunities has decreased in direct relation to the increase in his music interest/social activities" ($_{\text{Mother}}$Colin$_{\text{Researcher}}$). This change in Colin was further highlighted at the end of year exam. He only studied for mathematics for "two minutes" and got mostly Merit rather than Excellence marks. Significantly, because of his placing in the class, he did not get an Honours award for the first time. His behaviour changed in class after the exam results came back and became more casual. He wrote in an end of year questionnaire that Mathematics was his worst subject in the exams.

Discussion and Conclusions

The stories told in this paper capture Colin at the start of 2006 as being very positive about mathematics. He has a mature and well-developed understanding of what mathematics is, and values it highly as a discipline for life-long learning. Colin loves mathematics as a subject but also, perhaps equally, because he feels he is good at it compared with his peers. Grades, marks, place in the class, and prizes, in particular, are all institutional narratives for declaring who Colin *is*, and they all reinforce he is one of the best mathematicians in the school. Furthermore, Colin has received a number of reinforcements

from teachers and peers to believe in himself as an excellent mathematician, strongly reifying stories that make up his actual mathematics identity.

For most of the year, Colin had a *role* in class of a top mathematician, a role again endorsed by himself, his teachers, the school, his parents, and his peers. This role can be seen as his designated identity, and therefore there were a number of expectations of Colin; doing extremely well in, or being the "best" in assessments, answering the teachers' questions, helping others, working consistently, being organised, behaving well, and always understanding everything in class.

The Gap Between Colin's Designated and Actual Identities

Until mid 2006, there was no discernable gap between Colin's actual and designated identities. He was fulfilling his role of being a top mathematician. During the year however, because of the role he had been given (designated identity), he felt he needed to continue to fulfil that role or prove himself in the classroom and at assessment time. This became more difficult to do because of a change in focus, absences, and a lack of study and application. He did not do so well in assessments, did not prepare for the exams, did not understand everything in class, and did not get the coveted Honours award for mathematics.

These instances can be seen as critical stories that would make Colin feel as if his whole identity had changed. Sfard and Prusak (2005) concur that assessment results that are not up to expectation have a particular capacity to replace stories that have been part of a student's designated identity. When there is a perceived and persistent gap between actual and designated identities there is likely to be a sense of unhappiness in that person. Colin began to experience negative affective responses to mathematics because of this new gap. He was no longer fulfilling the expectations of his role, or his designated identity. Colin began to show negative affective responses to mathematics for the first time. He became anxious when he did not know immediately how to do something, he worried about what his parents might think about his results, and his behaviour changed in class. There was erosion in his emotions and feelings about mathematics and a concurrent drop in performance.

This is early in the story of the gap between Colin's actual and designated identities, and he, in general, remains very positive about mathematics and he continues to value it highly, but he has lost some of the positive feelings he got from being good at it compared with his classmates. Repeated instances of this could lead to negative change in his stable beliefs and values, particularly when he starts the assessment driven Year 11 NCEA Level One in 2007.

Lessons Learnt from Colin

This is Colin's story (or stories) and the lessons learnt from Colin need to be considered in terms of other students. Angela, for example, continues to have very little gap between her actual and designated identities. She however is different from Colin because she values doing well in the subject more than enjoying and valuing the subject itself. If she is unable to maintain her designated identity, there is likely to be higher consequences than for Colin in terms of increased negative affective responses and related learning outcomes or choices. Other students who are not viewed as top mathematicians (designated identity), but whose results and class work indicate they are excellent mathematicians (actual identity) feel excluded and as a result feel compounding frustration because of lack of acknowledgement. Average mathematicians in the class have the strongest negative affective responses,

perhaps compounded by their utter exclusion from the top group of mathematicians, class discussions, and their own reinforced and very much endorsed role as low in the class.

Colin's teachers from the last few years are significant narrators in his story and therefore are strong reinforcers of Colin's role of a top mathematician. Although the teachers' reinforcements may be seen as having high expectations of Colin, they need to be aware that a student's identities are being re-shaped constantly. A teacher therefore can exacerbate expectations that may become unrealistic for a developing, and sometimes mecurial, adolescent. Teachers, as both professionals and mathematics educators, need to understand and take responsibility for not only the effect that this reinforcement has on the individuals they perceive as being the best, but also the effect it has on the learning environment, and the other students in the class.

By capturing Colin's multiple mathematical identities, a context is provided for understanding his affective responses in mathematics. Colin's rare, but increasing, instances of negative affective responses can be seen as a result of a gap between his designated and actual identities. Other students too are affected by a gap, which contributes to their greater level of negative affective responses. By understanding these gaps, and especially the impact that a teacher can have, students with a potential gap can be identified, and the students helped to become more resilient to negative affective responses in mathematics.

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