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Using a narrative approach to study the transition to higher-level education

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ABSTRACT

This paper presents the results of a longitudinal study into the mathematical identity of science and engineering students (MISE) in Dublin City University. The goal of the research was to expand on previous mathematical identity research in Ireland by including science and engineering students since they study a significant amount of mathematics at university level.

Mathematical identity is considered to be one's relationship with mathematics, including knowledge of the subject and perception of oneself and others (Eaton & OReilly, 2009, p. 228). This qualitative study was conducted over four years using a narrative approach to mathematical identity (Radovic, Black, Williams & Salas, 2018, p. 29). The study involved 32 participants from science and engineering courses in DCU, including several students of science education who have since qualified as teachers. All participants completed an online open-ended questionnaire on mathematical identity in their first year of university. A further five participants contributed to focus groups and six participants took part in narrative interviews at the final stage of data collection. The conclusions are derived from participants' mathematical identity narratives which were developed through several stages of data collection involving both thematic and narrative analysis.

The findings highlight several issues that affected multiple participants and may affect a broader cohort of students than were included in the study. We also present some unique features of mathematical identity that arose in this context as students transitioned to higher-level education.

KEYWORDS

Mathematical identity, narrative inquiry, narrative analysis, transition, thematic analysis

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Introduction

While competing definitions of mathematical identity exist (Darragh, 2016) research on this topic has grown in prominence in recent years and it is widely recognised as an important concept for explaining why people may disengage from, or persist with, the learning of mathematics (Graven & Heyd-Metzuyanim, 2019). This paper is drawn from a larger PhD study, the title of which is *Mathematical Identity of Science and Engineering students* (MISE). Its purpose is to explore science and engineering students' relationship with mathematics and the contexts that inform this relationship as they transition to higher-level education. Researching mathematical identity in this context is important for a number of reasons. The primary purpose of this research is to explore learners' mathematical identities (Radovic et al., 2018). Existing research in the Irish context has tended to focus on the mathematical identity of teachers or student teachers engaging in teacher education (cf. Eaton et al., 2014). Moreover, exploration of mathematical identity as students transition to higher education may give insight into the policies and practices universities might put in place to support students' successful transition.

The MISE study, a study conducted in the narrative paradigm, will report on the longitudinal change in mathematical identity that was observed over several stages of data collection spanning four years in total. In this paper, reflexive thematic analysis (Braun & Clarke, 2022) was used to unpack how a particular theme, *Ways of Learning Mathematics*, developed over the course of the study. The importance of this theme has long been established in the literature (cf. Skemp, 1976) and has been a recurring theme in research on mathematical identity (Eaton & OReilly, 2009; Machalow et al., 2020). Furthermore, focusing on this one dimension of the MISE research, allows us to illustrate the methods of the larger study, and to explore self-identified differences in ways of learning mathematics across the different cohorts (Science and Engineering students), and across time.

Literature Review

Darragh's (2016) comprehensive review of identity research in mathematics education traces both sociological and psychological framings of identity, where identity can be seen, respectively, as an action or as an acquisition. Recent research on mathematical identity largely draws on socio-cultural theories of learning (Graven & Heyd-Metzuyanim, 2019). While a common critique of (mathematical) identity research is the lack of attention to clear definitions of identity (Darragh, 2016; Sfard & Prusak, 2005), narrative is sometimes theorised to contribute to identity and has been identified as one of four theoretical approaches to the study of identity, the others being poststructural theory, positioning theory and psychoanalytic theory (Langer-Osuna & Esmonde, 2017). In some cases, identity is considered to equate with narrative. Sfard and Prusak (2005) operationalise identity as significant, reified, and endorsable stories about a person, or "the product of collective story-telling" (Graven & Heyd-Metzuyanim, 2019, p. 363). While this view of identity as narrative is widely cited within mathematics education research, the full implications for methodology are not often realised (Graven & Heyd-Metzuyanim, 2019).

In this paper, mathematical identity is conceptualised as the multi-faceted relationship that an individual has with mathematics, including knowledge, experiences and perceptions of oneself and others (Eaton & OReilly, 2009). This definition was inspired by Grootenboer and Zevenbergen (2008) who proposed that identity incorporates students' "knowledge, abilities, skills, beliefs, dispositions, attitudes and emotions" (p. 244). We adopt a narrative approach to the study of identity as outlined by Langer-Osuna and Esmonde (2017). In particular, we

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maintain that the creation of narratives or stories is a key means of making sense of experience, and that mathematical identities develop as people make sense of their experiences.

In this paper, we consider higher-education students' mathematical identities in terms of how they discuss ways of learning mathematics. Conceptions of the nature of mathematics itself often underpin assumptions about how mathematics should be taught and learned. Ernest (1989) compares the instrumentalist view of mathematics, where mathematics is seen as a set of unrelated, utilitarian rules and facts; the Platonist view of mathematics, where mathematics is seen as a static but unified body of knowledge; and the view of mathematics as a cultural product, dynamic and continually expanding. He draws connections between these views of mathematics and associated views of teachers and learners. Models of teaching and learning can foreground the role of teacher as instructor (focus on skills mastery and students' compliant behaviour and reception of knowledge); explainer (focus on conceptual understanding and students' active construction of understanding); or facilitator (focus on problem posing/solving and students' autonomous exploration and learning). Arising from Skemp (1976), the contrast between relational or connected, conceptual understanding of mathematical ideas, and instrumental understanding, where disconnected rules and procedures are understood, has long been a focus in mathematics education research. Previous research on mathematics identity in Ireland has drawn attention to pre-service teachers' "broadly Platonist conceptions" of the nature of mathematics, but recognised the preference for instrumentalist or problem-solving views among some participants (Eaton et al., 2011, p. 40). It is argued that the instrumentalist view of mathematics is one that prioritises doing over understanding and results in students who struggle to "make connections between mathematical topics across different contexts or in unfamiliar problems" (p. 31). When it comes to affect, Machalow et al. (2020) showed that relational learning opportunities lead to positive narratives among pre-service teachers (PSTs) while instrumental learning opportunities lead to fragile or negative narratives.

Methods

The sample for the study consisted of 32 participants from science and engineering courses in DCU, including several students of science education who have since qualified as teachers. A series of previous studies in Ireland developed an online open-ended questionnaire for exploring mathematical identity of PSTs (Eaton & OReilly, 2009) which was adapted for this new context. The questionnaire consists of a broad opening question, a follow-up question which includes some prompts and a final evaluative question. All participants (in this study) completed the online questionnaire in their first year of university. In their third year, a further five participants contributed to focus groups. In their fourth year, six participants took part in narrative interviews for the final stage of data collection. These stages are shown in Table 1 below.

Table 1. *MISE Data Collection Timeline*

Data Collection Stage	Year	Semester
Questionnaire	1	II
Focus groups	3	I
Interviews	4	II

Narrative interviewing is a method of data collection that facilitates co-construction of meaning between interviewer and participant (Mishler, 1991, p. 52). We were drawn to

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narrative interviewing because "[t]he goal of the narrative interview is to get the interviewee to tell stories about things that are important to him or her" (Kaasila, 2007, p. 207). Although the interviews were semi-structured (there were some pre-prepared questions), participants were afforded the opportunity to direct the course of the interview rather than confining control to the interviewer (Cohen et al., 2007). To empower participants to do this, one must change the traditional interviewer-interviewee relationship to one of listener-narrator (Mishler, 1991, p. 117). In narrative interviews, participants are allowed time and space to "hold the floor"' (Coffey & Atkinson, 1996, p. 56) more than usual and organise their responses into stories. This is not prioritised in traditional semi-structured interviews where "there is usually not enough scope for recounting narratives" (Kaasila, 2007, p. 207).

The questionnaire and focus group data were analysed using thematic analysis to establish themes one of which, *Ways of Learning Mathematics*, was applied to the interview data for the purposes of this paper. The latter step involved identifying instances of the existing theme in the interview data.

Braun and Clarke have indicated that the underlying assumptions or philosophy (ontology, epistemology and theoretical perspective) influence one's approach to thematic analysis (Braun & Clarke, 2022, p. 157). They have recently introduced the term reflexive thematic analysis to clarify some of the misconceptions regarding the flexibility of the method, as they see it. Qualitative epistemologies can be thought of as a continuum, with constructionism and subjectivism at its extremes (Crotty, 1998). This study was conducted under a narrative paradigm which is informed by a constructionist epistemology. According to this viewpoint, researcher and participant are "partners in the generation of meaning" (Crotty, 1998, p. 9) and knowledge of mathematical identity is co-constructed. This is relevant because the co-construction of meaning in reflexive thematic analysis necessitates a constructionist approach (Byrne, 2021, p. 5)

While recurrence of themes is a basic requirement in any form of thematic analysis, in reflexive thematic analysis the subjectivity and reflexivity of the researcher is vital in selecting which codes and themes are meaningful. For instance, a theme which is reported by only a few participants may be considered meaningful in the light of the research questions or the conviction of the participants' responses (Byrne, 2021, p. 5). Thus, the conclusions presented in this paper should be seen as situated in context and, consistent with the approach outlined by Braun and Clarke (2022, p. 145), we do not seek to make claims about the generalisability of the results beyond this context. In addition, Eaton et al. (2014, p. 370) have previously demonstrated that the relevance of a theme (or 'aspect' to use their terminology for sub-themes) related to mathematical identity can vary for different cohorts of students.

Analytic Narratives

First year

At this early stage of their higher-level education, participants tended to focus on their mathematical experience at post-primary level. They made a distinction between two types of learning: doing mathematics and understanding mathematics. In contrast to the instrumentalist view of mathematics discussed earlier, MISE participants had experienced, and disliked, doing tasks without any element of understanding, what Skemp called "rules without reasons" (1976, p. 20). They celebrated the benefits of combining both forms of learning:

Once I started to actually understand maths, rather than just do it, I began to really enjoy it. (ID066)

Understanding the maths we were studying instead of just learning off an equation. This definitely helps me … now. (ID054)

Other participants decried being “told to do questions in the book with no explanation” (ID076), or learning without hearing the “reasoning behind what [they] were doing” (ID118). Classroom experiences that lacked these elements were viewed as hollow, frustrating and lacking purpose since “we just learned it for the sake of learning” (ID118).

MISE participants contended that understanding mathematics frequently involves a higher level of thinking, one where students are familiar with the “underlying concepts” (ID015) and, almost exactly quoting the definition given by Skemp (1976, p. 20), understand “what to do, and why to do it” (ID086). This approach has been shown to induce a positive affective response through students feelings and motivations (cf. Machalow et al., 2020).

Participants placed great value on their teachers’ ability to explain mathematics to their students since “grades are also highly dependent on the teacher/lecturer … simply the teacher is bad at explaining” (ID021). One participant chose to move into the higher-level mathematics class and thrived there because they identified that their new teacher had this skill:

I found that teacher very bad in terms of her ability to explain maths. I moved myself to higher mathematics. … That teacher was very professional and talented at explaining maths, for me it became easier to understand maths. (ID086)

Combined, these two participants link good explanations to both results and understanding. This emerged as an early hint at a characterisation of understanding which will be made clearer in the next section: you understand it if you can explain it to someone else.

Overall, while reflecting on the teaching they experienced participants' emphasised that doing should be balanced with understanding in the classroom but that “[t]he importance of learning through concepts rather than through questions should be stressed a lot more” (ID066). It was surprising that participants presented no evidence of working collaboratively in mathematics at this point of their studies. Since this has featured prominently in other research on mathematical identity (Eaton & OReilly, 2009), it was important to be alert to the possibility that this would change as they transitioned to higher-level education.

Third year

In the focus groups, participants still saw the distinction between the two types of learning described above: “Do this, do that instead of actually understanding … the how and the why get lost” (ID083). Three PSTs were clear that in the post-primary classroom, understanding mathematics is manifestly separate to being able to answer questions, and they may need to balance the two when teaching:

If you can do a question, it doesn't necessarily mean you understand it. (ID046)

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> *Well and good to be able to do … a question but once it's applied to a real-world situation, you being able to know which formula or whatever to use. (ID083)*

> *Like, you don't necessarily teach for your students to have an understanding, you teach that they have an ability to answer questions. (ID084)*

While learning mathematics at university level, participants continued to reject the instrumentalist view described earlier, and emphasised that understanding means going further than being able to answer questions and pass your university exams:

> *Understanding it means going deeper, understanding how things work from the fundamentals. … then you're going to apply the theorems or specific rules, or algorithms to solve a wider range of problems. (ID122)*

For this engineering student, this philosophy was reinforced by the format of their end-of-year exams. Unlike in tutorials or assignments, "they give us unseen problems that we have to try to solve using the theory that we've been taught … We have to find our own way of solving them" (ID122). Not only this but they "regularly apply the same [mathematical] tools in other modules" (ID122).

One PST agrees that being able to "take something from another section and use it here" (ID083) means their students understand the mathematics they have learned: they can see the connections between different topics (cf. Skemp, 1976, p. 8). A science student similarly noted that "you really had to pull maths from like a bunch of different areas" (ID125), and confirmed that the concepts and methods from their mathematics modules arise "outside of actual maths itself" (ID125). The same participant provided this plain-language characterisation of understanding: "I feel like you definitely understand it if you're able to fully explain it to someone else and they get it" (ID125).

Fourth year

In fourth year, narrative interviews were used to draw-out participants' interpretations of their experiences in university, and how their mathematical identity had changed over that time. The distinction between understanding and doing persisted but despite the enthusiasm with which MISE participants seek out both types of learning, there were examples of modules where they had to forego this approach:

> *I learned off that this is what I have to, do you get me? But I never knew why I was doing it. I didn't understand it. I just kind of had it drilled into my head ... Whereas with maths with [a different lecturer] I'd understand say 90% of things as [they were] teaching them. (ID112)*

> *I found myself out of my comfort zone … I kind of approached it differently than I did the other modules. … I could answer the question fairly adequately but if the second part of the question was 'explain why it works,' I was just totally out.(ID084)*

This suggests that students may feel they have to rote learn mathematics due to the complexity of a module. However, the teaching style of the lecturer can have an influence

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also . One participant insisted that in one module they were pressured into replicating exact solutions in work submitted for assessment:

> *There's one way to do it, you do it any other way, no matter if it's right, you're not getting marks. I didn't like that. (ID031)*

In the previous section, a PST noted that in the classroom, teachers may forego teaching for understanding in favour of ensuring their students can answer questions. This pressure may influence lecturers at university level also.

This dataset revealed some insights into the ways that MISE participants began to collaborate with their classmates over time. However, a science student describes how they were "pretty much just working on [their] own" and that this may actually have benefitted them when it came to progressing through university:

> *But in terms of like my own development in my own course, I think working alone definitely suits me better, yeah. (ID125)*

Another engineering student shares the view that working alone can be better: "I wouldn't say that I'm a team player. Like a lot of things, I like doing it on my own or I like it being done my way" (ID112).

Although their final year project allowed them the space to work this way, they describe "other modules where you have to work as part of a team and people don't pull their own weight," (ID112) which suggests that engineering students don't have the option to "do it on their own." Engineering students also collaborated on assignments where they would "kind of compare answers, just to see if we were getting them right …. Then, it would turn into a big argument if someone thought they were right over someone else (ID112)"

In contrast with their working patterns in first year, PSTs "did the assignments together" (ID031) as well as exam papers, and even "just general, kind of keeping up with content of ehm modules and stuff" (ID046). Unsurprisingly, this change is seen as entirely positive by MISE participants: "I like the support network, I like bouncing off … my friends first. … it was nice having that small network" (ID046).

Discussion

This paper presents Science and Engineering student's views on the distinction between doing questions/exams (instrumental understanding) and understanding mathematics (relational understanding).

For MISE students, understanding means being able to explain, recognising useful concepts and methods in other contexts and knowing what to do, and why. Engineering students describe how their final exams feature unseen problems, for which these skills are useful. However, most participants are seldom given the opportunity to demonstrate these skills in final exams and still resort to instrumental learning when they feel it is required.

In first year, participants found common ground in rejecting instrumentalist mathematics, based on their experiences at post-primary level. Although most participants appeared to describe mathematics as an individual pursuit in first year, by final year a support-network of collaboration was more common. Participants' views on what it means to understand mathematics appeared to become more precise and clearer over time, as demonstrated in the analytic narratives for the second and third stages of data collection. This is particularly the case for PSTs whose mathematical identity was influenced by their teaching experiences and their evolving views of teaching and learners.

The results of this study demonstrate the power of using narrative methods to collect rich data about students' mathematical identities as they transition to third level. We suggest that participants' desire to understand mathematics beyond answering exam questions could be nourished by using different forms of assessment (individual and group work, continuous assessment and exam conditions) for both formative and summative work.

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