Developing an Instrument to explore Mathematical Identity: A Study of Students from several Third Level Institutions in Ireland

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Developing an Instrument to explore Mathematical Identity: A Study of Students from several Third Level Institutions in Ireland

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Abstract: This paper presents collaborative work of a team of five researchers from five institutions on the island of Ireland in designing and implementing an online instrument to explore the Mathematical Identity of students in a flexible, yet efficient manner. The central notions of Mathematical Identity and narrative are presented and discussed in the context of different perspectives from the literature. The authors report on data, both qualitative and quantitative, gathered in the second quarter of 2013 from students in four third level institutions, and initial findings arising therefrom. There is evidence that many respondents expressed significant insight into learning and teaching mathematics and into their attitude to the subject as a result of using the instrument. The potential of the instrument for raising students' awareness of issues related to teaching and learning mathematics is promising.

Keywords: Mathematical Identity, narrative, online instrument, insight

Introduction

Mathematical Identity is considered as the multi-faceted relationship that an individual has with mathematics, including knowledge, experiences and perceptions of oneself and others (Grootenboer, Smith, and Lowrie, 2006; Kaasila 2007; Sfard and Prusak 2005; Wenger 1998). This paper offers a preliminary report on a collaborative study, Mathematical Identity using Narrative as a Tool (MINT), carried out on the island of Ireland by a research team of five colleagues from different higher education institutions. They are the authors of the paper. The project is based on two earlier projects involving three members of the team. One project focused on the Mathematical Identity of pre-service primary teachers specialising in mathematics; the other addressed undergraduate mathematics students taking modules on mathematics education. Results from both projects have been presented at ATEE conferences (Eaton and OReilly 2010, 2012; Eaton, Oldham, and OReilly 2012).

For MINT, the investigation of Mathematical Identity is extended to a broader cohort of students at the research team members' institutions. Building on the previous work, the research emphasizes the role of *narrative*, using the students' own stories of their

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encounters with mathematics and their relationship with it to explore their *Mathematical Identities*.

This paper focuses on the development of the instrument used to gather information and on presentation of the first results from using the instrument with higher education students. The findings refer in particular to the level of student engagement with the process and the students' reported insights gained through completing the instrument.

Theoretical Framework
The theoretical framework for the study comprises two aspects: Mathematical Identity and narrative. They are discussed in turn.

Mathematical Identity
Our notion of Mathematical Identity emphasises the relationship an individual (especially a student) has with mathematics. This notion has much in common with Wenger's social learning systems (Wenger n.d.), but has identity centre-stage and considers how knowledge, community and learning (to use Wenger's terminology) relate to identity. Moreover, the notion focuses on what relates to mathematics and so does not have the breadth associated with identity as treated by Wenger (1998), for example. Our approach is, in a sense, not as ambitious as that of Sfard and Prusak (2005) where these researchers seek to use identity as a tool to investigate learning, equating identities with narratives. Instead, we choose to use narrative as a tool to reveal identity, the relationship an individual (or indeed a group) has with mathematics. This stance draws also from the work of Kaasila (2007, 206): 'One's mathematical identity is manifested when telling stories about one's relationship to mathematics, its learning and teaching.' Like Kaasila, we acknowledge the close relationship between identity and its telling, yet we fall short of Bruner (1991) who contended that our personal narratives are our identities. It is our expectation that using narrative as a tool to disclose Mathematical Identity will be useful in encouraging insightful reflection by students, for example, and, in particular, pre-service teachers (Eaton and OReilly 2009a).

Wenger's work on identity can be traced back to his collaboration with Lave (Lave and Wenger 1991). In mathematics education, this work was developed in different ways by Boaler and Greeno (2000) who explore how identity allows access to different mathematical "worlds", by Walshaw (2004) who examines pre-service primary teachers' constructions of themselves as mathematics teachers, and by Graven and Lerman (2003) who make explicit the challenge for mathematics education in their review of Wenger's seminal work. Graven (2004) applies Wenger's theory to teacher learning, extending it to include the notion of (teacher) confidence. Smith (2006, 621) applies the theory to mathematics teacher education, that 'middle ground' allowing 'the creation of a personal position where different ways of knowing and being can coalesce in productive ways'. Grootenboer, Smith and Lowrie (2006, 612) see the potential of the concept of identity to connect diverse elements (such as beliefs, attitudes, emotions, cognitive capacity and life histories) in mathematics education. This last paper, in particular, acknowledges the diversity of scholarly communities using psychological, sociocultural, and postmodern lenses with which to explore identity.

Independent (or so it would appear) of the Wenger school is the work of Drake, Spillane and Hufferd-Ackles (2001) who present the notion of a person's identity being understood as and through stories. In the context of the work of the US National Council of Teachers of Mathematics (NCTM), these authors consider identities in learning and teaching both literacy and mathematics; they notice common threads arising from the stories of mathematics teachers that they expect to inform future policy. Collopy (2003, 289), drawing on this work, describes a 'teacher's identity [as] the constellation of interconnected beliefs and knowledge about subject matter, teaching, and learning as well as personal self-efficacy and orientation toward work and change.' Philipp (2007, 259) uses the working definition for identity (p. 259): 'The embodiment of an individual's knowledge, beliefs, values, commitments, intentions, and affect as they relate to one's participation within a particular community of practice; the ways one has learned to think, act, and interact.' In this definition, we can see evidence of influences from several of the sources above.

DiME (2007, 409) notes that Sfard and Prusak (2005) point out that the field of mathematics education has yet to agree upon a working definition of *identity*; however, they (DiME) find it makes sense to follow Wenger (1998, 145) in proposing that, 'identity serves as the pivot between the social and the individual.' So, having returned to the researchers cited at the start of this discussion, we find our own working definition given at the beginning of this paper has served us well and continues to promise rich fruits as we apply it to our research across several institutions in Ireland, North and South.

Narrative

In their seminal work, *Narrative Inquiry*, Clandinin and Connelly (2000, p. 80) ask, 'Why use narrative inquiry?' They answer, 'Because narrative inquiry is a way, the best way we believe, to think about experience.' They reiterate this point six years later: 'Narrative inquiry, the study of experience as story, then, is first and foremost a way of thinking about experience' (Connelly and Clandinin 2006). Kaasila (2007, 205), in a similar vein, asks, 'Why are narratives so important? The answer is simple: we live in a world of narratives.' These authors set the scene for the use of narrative in MINT. In the case of a newly qualified teacher (Ulla), Lutovac and Kaasila (2009, 7) note that through narratives, 'we can see the development of Ulla's mathematical identity.' This also resonates well with MINT, *using narrative as a tool*.

As we have seen in the discussion above on identity, Sfard and Prusak (2005, 17) take a different stance: 'we suggest that identities may be defined as collections of stories about persons.' Just as these authors use identities (equated with narratives) as 'a tool for fathoming the mechanism through which the wider community ... impinges on its members' learning' (p. 19), we prefer to pursue a line of investigation closer to that of Kaasila and his collaborators. In doing so, we do not reject the insights of Sfard and Prusak, but rather seek to find a discursive space where these different stances can not only coexist, but bring richer insights to experience, identity, narrative and learning in relation to mathematics, both for the individual and the 'wider community.' Sfard and Prusak (2005, 17) suggest that the approach of Wenger (1998) to identity is "essentialist" and undermines its "dynamic nature". We do not see this as necessarily so. Nonetheless, we are inclined to support the view of Sfard and Prusak (2005, 17) that 'identities are human-made and not God-given, they have authors and recipients, they are collectively shaped even if individually told.'

We do not seek to reconcile any of the tensions, explicit or implicit, of these or other authors, but seek to gain access to that fluid world of students' Mathematical Identities through narrative, stimulating their recollections of how their relationship with mathematics evolved over time. In creating a space for this to occur, we have found it helpful to value the use of the open-ended prompt, "Tell me..." (Riessman 1993; Eaton and OReilly 2009b).

Background

MINT (Mathematical Identity using Narrative as a Tool) developed from two earlier studies: Mathematical Identity of Student Teachers (MIST) and the study referred to here as the 'Bridging Study' because of its role in leading from MIST to MINT. Here, we consider their design and evolution insofar as they are important for the discussion that follows.

MIST was carried out at two institutions, Stranmillis University College (SUC) in Northern Ireland and St Patrick's College, Drumcondra (SPD) in the Republic of Ireland. It was funded by the Standing Conference on Teacher Education North and South (SCoTENS), a body that supports joint research on teacher education in the two jurisdictions on the island of Ireland. The first and last authors of the present paper carried out the research. It focused on the Mathematical Identity of student teachers who were intending to teach at primary level and who were specialising in mathematics (Eaton and OReilly 2009b).

The Bridging Study was built partly on MIST and partly on work involving mathematical autobiography carried out over many years by the fourth author (see Eaton, Oldham, and OReilly 2011). In this case, the students were undergraduate mathematicians at Trinity College, Dublin, who had elected to take modules in mathematics education. As part of the assessment of these modules, the students were asked to write their mathematical autobiographies, using the two-part MIST protocol (see below) to guide their responses.

To elicit students' narrative, the following two-part protocol was used in both MIST and the Bridging Study:

P1. Think about your total experience of mathematics. Tell us about the dominant features that come to mind.

P2. Now think carefully about *all stages* of your mathematical journey from primary school (or earlier) to university mathematics. Consider:

- Why you chose to study mathematics at third level
- Influential people
- Critical incidents or events
- Your feelings or attitudes to mathematics
- How mathematics compares to other subjects
- Mathematical content/topics

With these and other thoughts in mind, describe some further features of your relationship with mathematics over time.

For MIST, students were given time to respond to P1 before being presented with P2; this afforded them the opportunity to write about their experience with little direction initially, and then (using P2) invited them to consider aspects of their experience from a second perspective (Eaton and OReilly 2009b; Eaton, McCluskey, and OReilly 2011). This open-ended invitation to students to write their story was preceded by a 'P0' intended to stimulate that narrative by responding to the following eight 5-point Likert items:

1. Mathematics is a challenging subject.
2. Mathematics is more difficult than other subjects.
3. I have had an overall positive experience of mathematics.
4. Mathematics is irrelevant to everyday life.
5. I find mathematics intimidating.
6. I'll need a good understanding of mathematics for my future work.
7. Mathematics is interesting.
8. I feel competent in mathematics.

These were distilled from the work of Dutton (1954), Aiken (1974) and Tapia and Marsh (2004), and influenced also by Fennema and Sherman (1976) and Macnab and Payne

(2003). Since analysing students' attitude to mathematics, *per se*, was beyond the scope of MIST, these items were not used other than to stimulate the narrative.

For the Bridging Study, the stimulus, P0, involved students being asked to reflect on and discuss their likes and dislikes with regard to mathematics and to identify its nature, individually or in groups (as they chose). The two-part protocol (P1 and P2) was then given as an exercise to be completed outside lecture time.

For MIST, the narrative texts (responses to P1 and P2) were analysed for recurring themes, and clusters of issues were identified in order to give some direction to subsequent focus group discussions. These were held in each college, with a total of nine students participating, four in one college and five in the other. The complete set of field texts consisting of the questionnaire narrative responses and the transcripts of focus group discussions was analysed to identify common threads and themes (Clandinin and Connelly 2000). Analysis of these narratives, using a grounded theory approach, led to the identification of seven themes (Eaton and OReilly 2009b).

For the Bridging Study, the analysis used the MIST themes as the starting point (rather than grounded theory on a *tabula rasa*). The results have been reported by Eaton, Oldham and OReilly (2011).

As work on the Bridging Study drew to a close, the question naturally arose as to whether the themes that arose in the MIST data would be found in the narratives of other student cohorts. However, replication of MIST and/or the Bridging Study more widely would need to be streamlined.

By developing an easily administered instrument to explore students' Mathematical Identity, and by testing it out, the research team aim to make the tool available for application in a variety of settings. Teachers/lecturers administering such a tool to their classes could be expected to tune in more acutely to their students' learning, and thus improve their own effectiveness as teachers. Moreover, through use of the tool, students' awareness of how their Mathematical Identity can influence their learning could be expected to sharpen, enabling them to enhance their agency as learners.

With these ideas in mind, the team was augmented to five, joined by researchers from the University of Limerick (UL) and the Dun Laoghaire Institute of Art, Design and Technology (IADT), both in the Republic of Ireland. SCoTENS agreed to support the new project, MINT, which has the following aims:

A1. To propose an efficient and effective protocol for third level mathematics educators to explore the Mathematical Identities of their students with a view to improving the teaching and learning of mathematics.

A2. To collaborate with researchers in institutions, other than SPD and SUC, in exploring students' Mathematical Identity.

A3. To extend the work on Mathematical Identity undertaken in the MIST project, thus giving insight into how the Mathematical Identities of different cohorts of student teachers compare with one another and with those of students in other disciplines.

To achieve these aims, the expanded team identified the following research questions for MINT:

Q1. Can Mathematical Identity be harnessed to deepen engagement by students in mathematics and its teaching?

Q2. Are there significant differences in Mathematical Identity between student teachers (from diverse backgrounds) and other students in Ireland? In particular, what are the characteristics of the Mathematical Identity of students from different third level institutions?

Methodology

Research Design

The design of MINT was based on the notions of Mathematical Identity and narrative (as explained in the theoretical framework above), together with modifications of the instrument used for MIST and the Bridging Study (as outlined in the background section). The expansion of the research team led to consideration of how the instrument might be adapted for a significantly larger number and more diverse cohorts of students across five institutions (later reduced to four for logistical reasons), in a manner that allowed for local flexibility within the context of a common approach.

Research Questions

Guided by the aims (A1-A3) and research questions (Q1-Q2) articulated in the original design of MINT, the team focused on two more specific questions to give impetus to the work:

- Does use of the MINT instrument provide students with any insight into how awareness of their Mathematical Identity might sharpen their learning and influence their attitude to mathematics?
- To what extent is there evidence of common characteristics relating to Mathematical Identity for different student cohorts?

Research Instrument
The most important new feature in the instrument design was to make it available online to allow for easy administration and data recording and to facilitate textual analysis. Demographic items on gender, institution, programme of study, year of study age, mathematics qualification thus far and grade achieved were included. The same Likert items (P0) were used as for the MIST study, as was the two-part protocol to elicit students' narrative (P1 and P2). To address the 'insight' question above, the protocol was extended to include a third open-ended item:

P3. What insight, if any, have you gained about your own attitude to mathematics and studying the subject as a result of completing the questionnaire?

Thus the resulting instrument was structured in three sections:

S1. An introductory section asking respondents to provide demographic information (as outlined above)
S2. The eight Likert items (L1-L8) as for the MIST study
S3. The three-part protocol inviting open-ended narrative responses (P1-P3).

Based on the experience in MINT and the Bridging study, the research team initially considered a completion time between 40 and 60 minutes was appropriate. After the questionnaire was piloted, this was revised to between 20 and 60 minutes, and was included as a guideline for time required to complete the survey in the introduction to the questionnaire.

Data Collection and Research Sample
Once ethical clearance for its administration was obtained in all five institutions, data were collected in four institutions, from six cohorts of students. In total, there were 99 respondents, as follows:

- IADT
  - Entrepreneurship students: 1st year students (19 respondents) of the Bachelor of Business (Honours) in Entrepreneurship and Management programme and the Bachelor of Business & Entrepreneurship programme.
  - Applied Psychology students: 4th year students (16 respondents) in the BSc (Honours) in Applied Psychology programme.
- SPD
  - BEd Primary students: Student teachers (26 respondents) who were in the 3rd year (final year) of the Bachelor of Education programme for primary teaching and who were not specialising in mathematics.
- SUC

    - BEd Post-Primary students: Student teachers (11 respondents) who were in the 1st and 2nd year of the Bachelor of Education programme for post-primary teaching and who were specialising in mathematics and science.
- UL
    - PE & Maths students: Student teachers (22 respondents) who were in the 3rd or 4th year of a concurrent four year BSc in Physical Education with Mathematics.
    - PDE Maths students: Student teachers (4 respondents) undertaking the Postgraduate Diploma in Education with Mathematics.

Some differences between the selected cohorts can be noted. Students in SUC and UL are studying to be secondary school specialist mathematics teachers. Students in SPD are studying to qualify as primary school teachers, while those in IADT are taking non-teaching programmes.

Data was collected between 16 April and 29 May 2013 using SurveyMonkey. Each of the researchers took responsibility for data collection in her/his own institution. Participation was voluntary in all institutions. The data was collected at a time when students were embarking on summer examinations; this is likely to have affected the overall response rate of 22%.

Data Analysis

SPSS was used to analyse the quantitative data: the demographic data, the responses to the Likert items, and the times taken in completing the instrument. The analysis of the substantive qualitative data (P1 and P2) – not addressed in this paper – will begin by an appraisal of the suitability of the themes identified in the MINT study for categorising this larger dataset. The third item (P3) was analysed, *ab initio*, using a grounded theory approach with SPSS and Excel to support the categorising process.

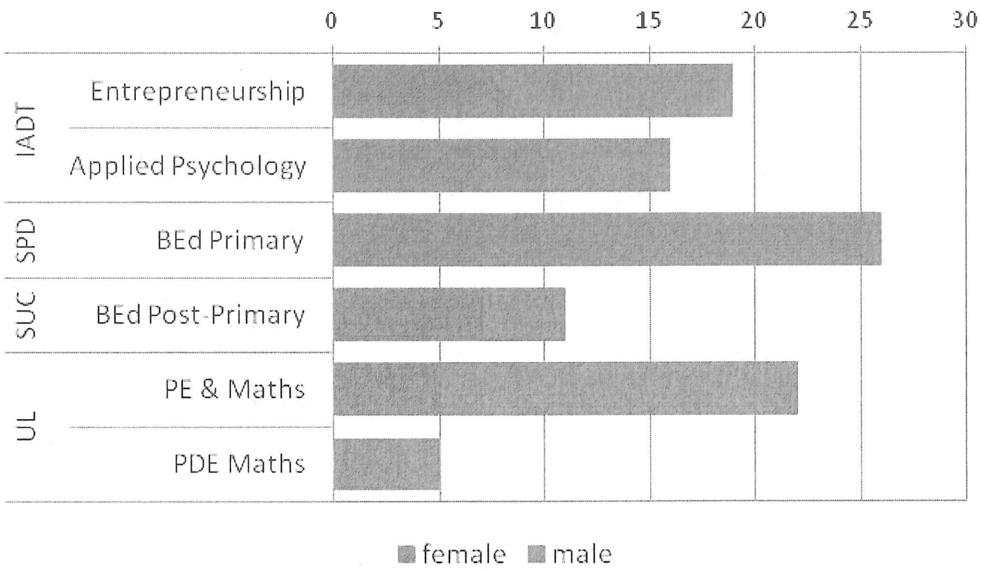
Findings

Quantitative Analysis

In this paper, we restrict the quantitative analysis to a brief presentation of the demographics, response times and lengths of responses.

There were 99 respondents. Most (80%) were in the age range 18-23 years, but 12% were in the range 24-27 years, while 8% were older. The distribution across the four institutions and six programmes is shown in Figure 1. Variability in gender balance across these programmes is evident: for example, the B.Ed. Primary cohort at SPD is predominantly female, while the PE & Maths cohort at UL is predominantly male.

Figure 1: Number of participants in the study by institute and gender



With regard to the time taken, the mean was 14.5 minutes with a median of 10 minutes, considerably lower than the time of 20-60 minutes envisaged and recommended by the research team. The distribution of the times taken by the participants to answer the survey is displayed in Figure 2.

Figure 2: Times taken by the participants to answer the survey by institution

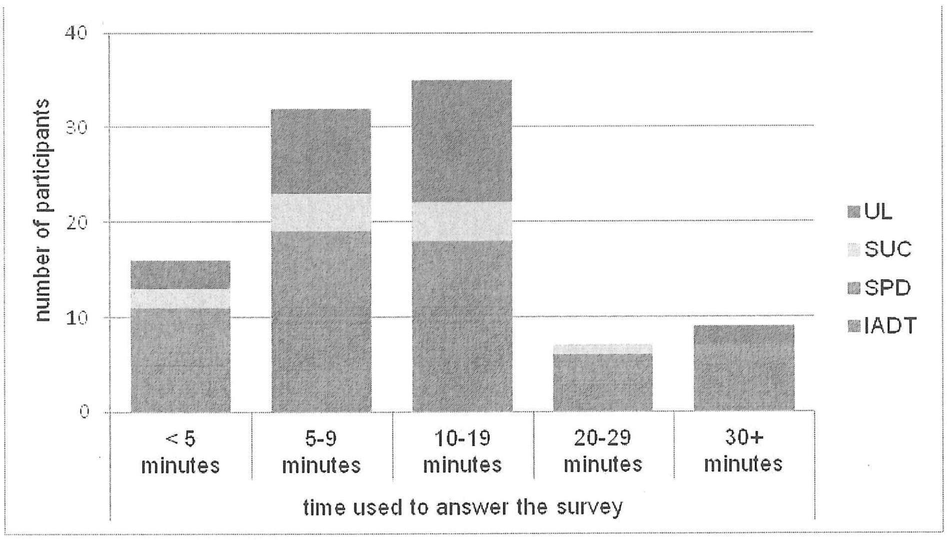


Figure 2 indicates a good spread of times spent to complete the questionnaire across the four institutions, with no strong differentiating characteristics emerging.

Of the 99 participants, 13 chose not to respond to any of the narrative questions. The number of words used to answer the three narrative questions (P1-P3, in section 3 of the questionnaire) ranged from 5 to 1050 words. Average total number of words for all three questions combined was 198. Fifty percent of students used between 100 and 244 words in total.

Qualitative Analysis

The focus of this paper is on the level of students' engagement with the instrument as expressed in the responses to P3, the third question in section 3: *What insight, if any, have you gained about your own attitude to mathematics and studying the subject as a result of completing the questionnaire?* To this end, four coarse categories (A-D) and a total of ten finer categories (0-9), ranging from 'no response' to a response reflecting deep engagement with meta-level issues, were identified as follows:

A. No response or minimal response
    0. Left blank or entered *none*.
    1. Entered *it's alright*.
B. No influence reported / apparent
    2. Entered *my opinions haven't changed*, or similar.
    3. Entered *it hasn't changed my attitude just made me dwell on my opinions of maths*, or similar.
    4. Entered *not much really*, or similar, followed by some **specific reflection**.
C. One insight or more, (perhaps) from completing questionnaire, but not focused on teaching / learning
    5. Identified **one specific insight** (without denying the influence of the questionnaire).
    6. Identified **several insights** (typically about *loving/hating* or *enjoying/dreading* maths), but without emphasising learning or teaching the subject.
D. Explicit attention drawn to their own learning, to teaching and/or attitudes to teaching mathematics
    7. Drew attention to their own experiences as learners and of what they valued in teachers.
    8. Drew attention to teaching and learning beyond their own experience, including their aspirations about how they themselves might teach.
    9. Drew attention to meta-issues by generalising from their own experience, encompassing, for example, significant changes in their own attitude towards maths or the importance of the subject in education in general.

After one author had assigned each response to exactly one of the ten finer categories, another author assigned the responses independently. The two authors agreed for 97 of 99 responses, showing a high inter-rater reliability. Here are examples of some responses in categories 5 through 9 (with the categories indicated and spelling corrected):

- *the insight I learned is that I don't really hate maths but I just don't necessarily like to do calculations* (5)
- *I prefer to use manipulatives and resources to develop an understanding of maths, as opposed to rote learning of definitions, formulae and theorems* (6 or 7)
- *I am continually being told how the new curriculum and the modern teaching strategies highlight conceptual understanding however I find myself wrestling with this because it is alien to me from how I have always been able to understand maths (through practice and repetition and learning).* (7)
- *I know that as a future maths teacher I don't want my students to have the negative experiences that I had through mathematics and hope that I can develop their interest in mathematics* (8)
- *This questionnaire has made me realise how my attitude towards maths has changed from third level education. It seems a reform of the education system of Maths is in order, rote learning is pointless, students should obtain an understanding of the concepts through examples which are relatable to learners' age.* (9)

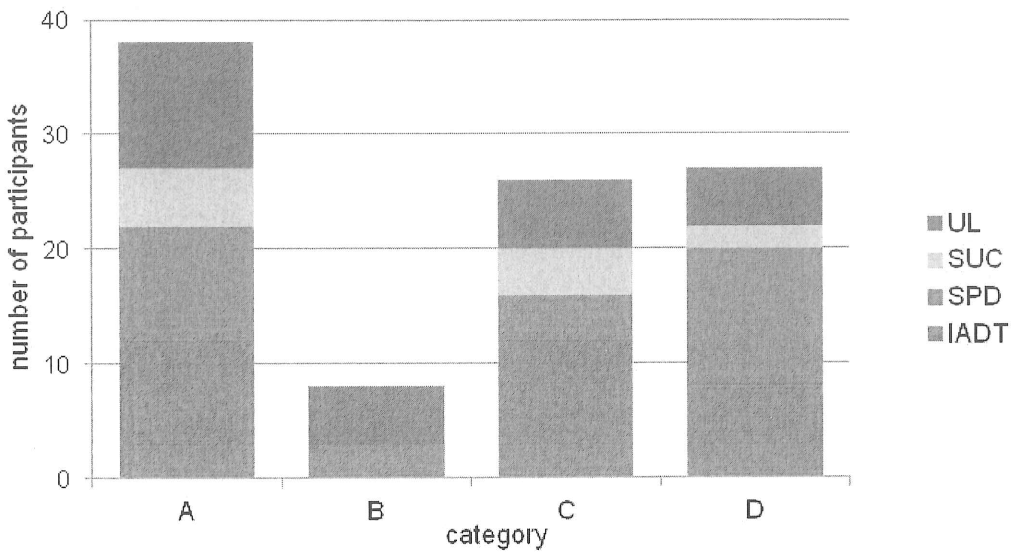
The frequencies for each category are given in Table 1 which indicates, once the 'no responses' have been excluded, that students demonstrated significant levels of insight in how they treated the question.

Table 1: Number of responses to P3 in each of the ten given categories

Coarse category	A		B			C		D		
Fine category	0	1	2	3	4	5	6	7	8	9
Number of responses	37	1	3	2	3	13	13	11	8	8

Now consider how the levels of response varied between institutions (Figure 3) and according to time spent in responding (Figure 4), using the four coarse categories.

Figure 3: Participants' response to P3 by category and institution



It can be seen that most levels of insight were represented in most institutions. A good proportion in each institution responded minimally (38.4% overall). Otherwise the institutional profile appears to vary significantly, with SPD students inclined to draw explicit attention to their own learning, to teaching and/or attitudes to teaching mathematics, while the responses of UL students are rather evenly spread across categories B, C and D.

Figure 4: Participants' response to P3 by category and time taken to answer the survey

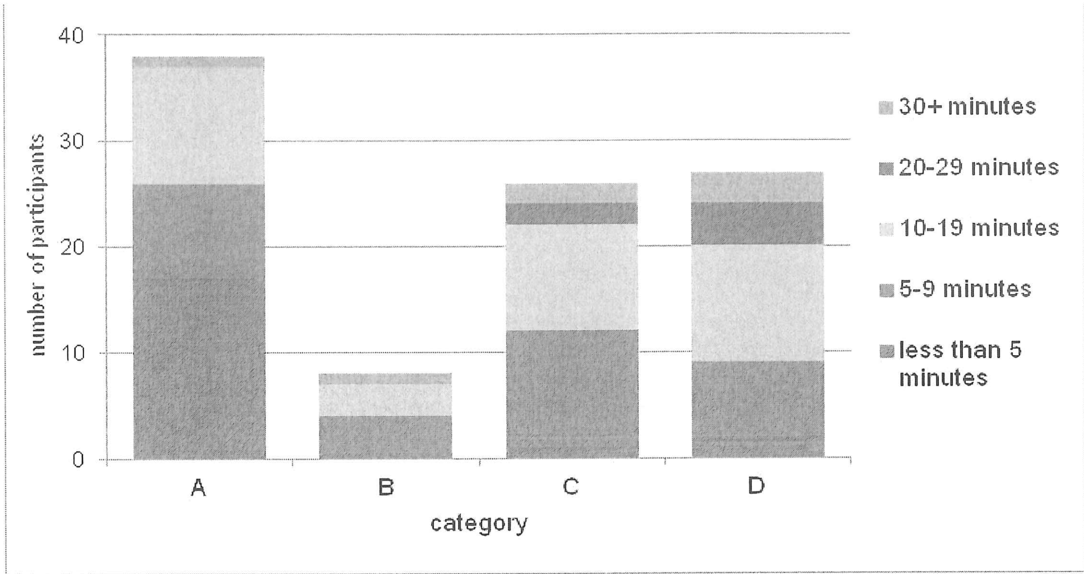


Figure 4 indicates that some responses taking no more than five to nine minutes contained illuminating reflective insights. Thus it does not appear necessary for students to spend a long time considering their responses in order for them to express significant insight.

Conclusion

This paper described the development of an instrument to gather information on the Mathematical Identity of higher education students and presented early results from its administration. The instrument was built on the authors' experiences with narrative questions from previous projects, but also included a variety of demographic information and some Likert-scale questions aiming to capture students' attitudes towards mathematics. It facilitates the comparison of different student cohorts and exploration of similarities and differences in narratives of students from diverse backgrounds. The online aspect allows for easy administration and automated capture of data for exploring Mathematical Identity. The first experience with the instrument showed that its setup and use by students is straight forward and therefore supports wider use in future.

One surprising result was the short time (on average 14.5 minutes) taken by most students to complete the instrument. However, even when giving as short a time as five to nine minutes, students demonstrated considerable insight, as a result of completing the survey, into their own attitude towards mathematics and studying the subject. Put another way, students can be both efficient and thoughtful in their response. This demonstrates the potential of the instrument to act as an effective tool to harness Mathematical Identity.

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