

**Not belonging: what makes a functional learner identity in the undergraduate mathematics community of practice?**

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## **Not belonging: what makes a functional learner identity in the undergraduate mathematics community of practice?**

Analysis of interviews with undergraduate mathematics students shows that 'not belonging' is a prevalent theme in their accounts of the experience of studying mathematics, despite the fact that their degree-level study labels them as 'good at maths'. This paper uses Wenger's communities of practice model to explore the range of mathematics identities in this group. It presents a typology of learner identities which demonstrates that most learners describe themselves as marginalised: they are aligned with mathematical procedures but do not contribute to them. It is rare to perceive oneself as a 'legitimate peripheral participant' - as a novice with the potential to make constructive connections in mathematics. Contrary to the expectations set up by Wenger's model, however, the apparently promising novice is not necessarily happy with their lot, while the heavily aligned student may in fact be unconcerned about their lack of participation. The data demonstrate how the institutional culture of entrenched beliefs about ability and ownership of knowledge affects students' experiences of being an undergraduate and dictates the functionality of particular identities.

### **1. Introduction**

Identity is central to any social theory of learning. As far as mathematics is concerned, it is essential to students' beliefs about themselves as learners and as potential mathematicians (Kloosterman & Coughan, 1994; Carlson, 1999; Martino & Maher, 1999; Boaler & Greeno, 2000; De Corte et al, 2002; Maher, 2005), and it has vital gender, race and class components (see Burton, 1995; Becker, 1995; Bartholomew, 1999; Boaler, 1997; Cooper, 2001; Dowling, 2001; Kassem, 2001; Black, 2002; Gilborn & Mirza, 2002; Cobb & Hodge, 2002; Nasir, 2002; Abreu and Cline, 2003). In this paper I will show how Wenger's (1998) analysis of the development of identity across communities of practice provides a useful initial framework for an exploration of undergraduate mathematics student identities. I first overview Wenger's model before applying it to twelve case study interviews in terms of the three modes of belonging – alignment, imagination and engagement – and combinations of these. Exploring student identities in this way emphasizes two important aspects of mathematics learning. Firstly, the model makes transparent the role of beliefs about mathematics

and mathematical abilities and their associated classroom practices in the development of identity. Secondly, gender differences emerge which suggest that classroom communities have a considerable effect on the interplay between identities of alignment, imagination and engagement, and how these are experienced. I will argue that what makes a functional identity in the undergraduate community of practice is not necessarily an identity of engagement as Wenger's model would initially imply. Paradoxically, within this community those students who aim for a more participatory role may in fact doubt their ability to continue as mathematics undergraduates.

## **2. Identity in a community of practice**

Wenger (1998, p.151) defines identity as 'a layering of events of participation and reification by which our experience and its social interpretation inform each other. As we encounter our effects on the world and develop our relations with others, these layers build upon each other to produce our identity as a very complex interweaving of participative experience and reificative projections'. Identity is experienced through the competences manifested in sharing a common enterprise, values, assumptions, purpose and rules of engagement and communication. Thus, because we come into contact with several practices, some of which we are full members of and some of which we are not, 'we know who we are by what is familiar, understandable, usable, negotiable; we know who we are not by what is foreign, opaque, unwieldy, unproductive' (p.153). Identity in this sense is not fixed, of course, and individuals move in and out of practices on a number of trajectories, sometimes on the way to full participation, sometimes as an insider participating in the evolution of a practice, sometimes as a peripheral participant, sometimes as one who spans the boundaries between practices, and sometimes on the way *out* of a practice (pp.154-5).

The notion of trajectories underlines the fact that identity is not static and is not solely composed of community membership and its associated competencies. Individuals are equally defined in terms of their non-participation in practices and movement between or within them. Thus, in addition to engagement as a 'mode of belonging' (p.173), Wenger invokes imagination and alignment as further aspects of identity. Imagination 'refers to a process of expanding our self by transcending our time and space and creating new images of the world and ourselves' (p.176). Its central feature is a standing back from direct engagement in the immediate practice and an

awareness of actions as part of historical patterns and potential future developments, of others' perspectives and of other possible meanings. In essence, this aspect of identity is one of self-awareness and self-reflection, a positioning of self within the social nexus of practices.

Alignment, on the other hand emphasizes common patterns of action. Wenger's examples of scientific method and educational standards which 'propose broad systems of styles and discourses through which we can belong' (p.180) are particularly relevant here. Thus we position ourselves through adherence to these more global practices. While alignment has a positive coordinating aspect, it also has an element of control, and as Wenger points out, it involves power – either to align oneself or in the demand for alignment from others.

The negative potential of alignment is obvious in the sense of individuals' disempowerment through the blind following and enforcement of rules, but imagination and engagement also have what Wenger calls trade-offs, although these are less conspicuous. Imagination can be used positively to assess, control and even resist the negativity of alignment through its grasp of the positioning of self, but imagination can also wrongly assume that stereotypes hold true or that others must see things as we do. Thus Wenger describes it as 'a delicate act of identity .. [which] ...runs the risk of losing touch with the sense of social efficacy by which our experience of the world can be interpreted as competence' (p.178). Engagement too needs to be counterbalanced by the positive creativity of imagination; it can become so narrow as to close down our ability to see from other perspectives or to stand back and reflect on the deeply embedded practices of which we are a part. Wenger thus describes a situation of stagnation in which 'competence can become so transparent, locally ingrained, and socially efficacious that it becomes insular: nothing else, no other viewpoint, can even register' (p.175).

It is the mix of modes of belonging and their related identities of participation and non-participation that constitutes, and is constituted by, the extent to which individuals identify with a practice and are able to control and negotiate meanings within it. Within the mode of engagement, positive outcomes for the learner are to be able to 'appropriate the meanings of a community and develop an identity of participation' (p.202); but it is also possible to exclude learners from the negotiation of meaning so that 'members whose contributions are never adopted develop an identity of non-participation that progressively marginalizes them' (p.203).

Within the mode of imagination, lack of access to a practice can become marginalisation as the individual assumes that meanings ‘belong elsewhere’ and will never be theirs to access. Finally, within the mode of alignment, while initial guidance and modelling introduces the learner to the possibilities of a practice (see also Solomon, 1998), lack of ownership generates and is generated by compliance and an emphasis on procedures (p.205). Thus we can see a source for what Edwards and Mercer (1987) and Mercer (1995) call ‘ritual knowledge’ as a product of teaching in which learners have no control and simply seek to supply teachers with ‘right answers’, relying on the ‘paraphernalia of the lesson’ as a prop which, when removed, leaves the learner without the ability to apply knowledge in new situations:

...literal compliance can be efficient, since it does not require the complex processes of negotiation by which ownership of meaning can be shared. But for the same reason, it is brittle in that it makes alignment dependent on an environment that is specifically organized, conforming, and free of unforeseen situations. Such lack of negotiability can only engender either strict alignment in terms of the reification or no alignment at all, which results in an inability to adapt to new circumstances, a lack of flexibility, and a propensity to breakdowns. (Wenger, 1998, p.206)

Thus alignment has a part to play in learning to be a participant in a community of practice. Without it, learners meaninglessly exercise imagination in a social vacuum. But ownership of meaning and the possibility of creating new meanings is necessary if individuals are not to become marginalised: they must retain the identity of the peripheral participant on an inward trajectory, rather than an identity of marginalisation. Wenger's account of the dual nature of identity reminds us that ‘Identification without negotiability is powerlessness - vulnerability, narrowness, marginality. Conversely, negotiability without identification is empty - it is meaningless power, freedom as isolation and cynicism’ (p.208).

### **3. Identity in mathematics communities of practice**

The role of identity in understanding exclusion from and also inclusion in mathematics is most visible in formal learning contexts where learners are subject to institutional structures which impose categorisations on them as good at or not good at mathematics via assessment, curriculum and classroom interactions. As Boaler (2002, p.132) points out, a situated perspective on learning underlines how ‘different pedagogies are not just vehicles for more or less knowledge, they shape the nature of the knowledge produced and define the identities students develop as mathematics learners through the practices in which they engage’. Many researchers

(for example Boaler, 1997, 2000, 2002; Burton, 1999; Fennema & Romberg, 1999; Maher, 2005) argue that traditional classroom mathematics teaching excludes learners, and that mathematics can only be made accessible to all in a participatory pedagogy which encourages exploration, negotiation and ownership of knowledge, all of which involve an identity shift for many learners. Closely related to pedagogic styles are teacher-pupil interactions and grouping systems: the experience of ability grouping has a major part to play in shaping mathematics identities in terms of the development for some pupils but not others of an identity of engagement which are reflected in different kinds of teacher-pupil interactions (Bartholomew, 1999). Faced with higher ability sets, teachers are more likely to focus on pupil learning and involvement with the subject, and to engage in between-equals banter. Of particular interest in the current context is the observation that girls in top sets are likely to be positioned and position themselves as having 'less right' to be there and to experience a high level of anxiety (see also Boaler, 1997; Boaler, Wiliam & Brown 2000).

In the post-compulsory years identity persists as an issue despite the choice element in studying mathematics beyond the age of 16. Gender and identity emerges as a major issue at this stage: for example, Landau (1994) notes girls' lack of confidence and the negative effects of accelerated GCSE courses, while Kitchen (1999) notes that gender is a major factor in the changing patterns of A-level maths entry, performance and transition to HE. Mendick (2003a,b; 2005a,b) also argues that 'doing mathematics is doing masculinity' – for girls, choosing to study beyond the compulsory years therefore involves considerable 'identity work'. When it comes to entering the university mathematics community, the development of learner identities reaches a new level of complexity. The under-representation of women in degree-level mathematics has been examined by a range of feminist researchers, most typically feminists of difference who have contested the exclusive masculinity of mathematics (see for example Becker, 1995; Burton, 1995; Rogers, 1995). Other writers (e.g. Bartholomew & Rodd, 2003) have explored the emotional aspects of young women's mathematics identities, arguing that the dominant discourses of mathematics make it difficult for women to acknowledge themselves as successful potential mathematicians. There are more general issues, however, which affect the majority of students, not just women: despite the fact that degree-level mathematics students are – by definition – 'good at maths', mathematics teachers complain that these students fail to engage

with the subject other than in an instrumental fashion (Hoyles et al., 2001; Alibert & Thomas, 1991), and that they see mathematics simply as a rote learning task (Crawford et al., 1994). Students who choose to study mathematics are defensive about their choice to do mathematics at university, tending to rely on 'being able to do it' and positive test results for their identity confirmation (Brown, Macrae & Rodd, in preparation). They thus display characteristics which are more closely indicative of learners on the margins of a practice, not learners on an inward trajectory towards engagement. As Brown & Rodd (2003) comment, successful students demonstrate a variety of ways of participating in mathematics, not all of them matching Wenger's engagement model. In the analysis which follows, I explore why this should be the case in this particular group of learners.

#### **4. The study**

##### *4.1 Participants*

The data presented here were collected in interviews with twelve first-year undergraduate mathematics students at an English university with a strong research culture. The students were self-selecting, having responded to a request delivered via their tutors to help with a project concerning mathematics learning in which they would get an opportunity to talk about their own study experiences. The participants represented a range of mathematics student profiles: ten respondents were aged 19-20, and included four women and six men; the eleventh was a twenty-three-year-old male mature student, and the twelfth was a thirty-four year old female mature student. Schools in England offer two mathematics qualifications between the ages of 16 and 18: students choosing to study mathematics take the Advanced Level General Certificate of Education in Mathematics, but some take in addition Advanced Level Further Mathematics, which builds on the material of the Advanced Level Mathematics syllabus. Of the regular age students all had taken Advanced Level Mathematics and one had taken Further Mathematics; both mature students had entered the university with a further education college access award in mathematics. Students at this university take up to three subjects in their first year of study, proceeding in their second and third years to study their chosen major subject or subjects (joint majors combining courses from two subject areas). All the participants were taking the basic first-year mathematics course offered at this university, but six were taking an additional mathematics option, compulsory for intending mathematics majors. Three students (one male, two female) were registered for a single major degree in mathematics, one (female) for a single major in environmental mathematics, two (both

male) for a joint degree in mathematics combined with computer science, one (male) for a joint degree in mathematics and management, one (female) for a combined sciences degree with mathematics options and four (one female, three male) for major degrees in other subjects with mathematics as a minor subject.

While all students enter the university in order to study a particular major or joint major degree, a small number opt to change their intended major at the end of their first year, pursuing instead another degree programme. Thus students are able to move from joint major degree schemes to single major schemes and vice versa, and also to change their major subjects altogether, providing they have taken the subject in question in their first year. Some of the students in the sample were intending to make these sorts of changes. The three mathematics single major students were intending to continue as mathematics majors into the second year of university and the environmental mathematics student was continuing in environmental science and taking statistics as a minor only. Of the three students who were combining mathematics with another subject as joint majors, one was continuing as joint, one was intending to take mathematics as a minor subject only, and one was intending to change from a joint degree in mathematics and computer science to a single major in mathematics. The remaining students – taking mathematics as a minor or as part of a general science degree - showed a similar variety of intentions. One notable instance was Richard's complete change of major from management to mathematics. These details are summarised in Table 1, which shows each participant's registered major on entry to the university, and their intended major for the second and third years of their degree.

*Table 1: Student profiles*

<b>Student name<sup>1</sup></b>	<b>Male/ Female</b>	<b>Registered major on entry: Mathematics majors/joint majors are in bold</b>	<b>Intended second and third year major subjects: Mathematics majors/joint majors are in bold</b>
<b>Carol</b>	<b>F</b>	<b>Environmental mathematics</b>	Mathematics minor only
<b>Debbie (mature)</b>	<b>F</b>	<b>Single major mathematics</b> RS minor	<b>Single major mathematics</b>
<b>Sarah</b>	<b>F</b>	<b>Single major mathematics</b> Art minor	<b>Single major mathematics</b>
<b>Larry</b>	<b>M</b>	<b>Single major mathematics</b>	<b>Single major mathematics</b>

<sup>1</sup> All names are pseudonyms.

<b>Pete (mature)</b>	<b>M</b>	<b>Mathematics/computer science joint</b>	<b>Mathematics/computer science joint</b>
<b>Steve</b>	<b>M</b>	<b>Mathematics/computer science joint</b>	<b>Single major mathematics</b>
<b>Joe</b>	<b>M</b>	<b>Management/mathematics joint</b>	Statistics minor only
<b>Sue</b>	<b>F</b>	Combined sciences (includes mathematics options)	Combined sciences, including mathematics
<b>Diane</b>	<b>F</b>	Geography	Geography
<b>Charlie</b>	<b>M</b>	Computer science	Communication studies
<b>Chris</b>	<b>M</b>	Natural sciences	Statistics minor only
<b>Richard</b>	<b>M</b>	Management	<b>Single major mathematics</b>

#### 4.2 The interviews

The students were contacted by e-mail and asked to come along to the interview with a selection of work, including a topic they had enjoyed and/or found easy, and a topic which they had disliked or found difficult to do. The interviews were semi-structured, lasting for approximately one hour each and focusing on the following issues: the students' 'mathematics histories' and comparisons between mathematics at school or college and at university, the effect of different teaching styles on their learning experiences, their experiences of getting 'stuck' and strategies for resolving problems, the topics they found easy or hard (students were asked to talk through the examples they had brought with them), comparisons with other subjects in terms of the kind of work expected and how they approached the subject matter and tasks, the students' reasons for choosing mathematics at university, their views on what kind of approach would lead to success in mathematics, and their perceptions of research mathematics and of themselves as mathematicians. The students were interviewed individually when they were approximately two-thirds of the way through their first year at university. The interviews were audio-taped.

#### 4.3 The analysis process

The interviews were transcribed in full and analysed thematically with assistance from Atlas-ti qualitative analysis software. This entailed assigning relevant pieces of text to categories initially generated from Wenger's theoretical framework outlined above, focussing on the broad categories of alignment, imagination and engagement. Repeated exploration of these categories and the connections between them revealed further complexities in the students'

positioning of self as mathematicians and indicated issues of importance in their classroom experiences; these are presented below with illustrative quotes (see Seale, 2000, for an analysis of techniques similar to those employed here).

## **5. Mathematics identities**

'Not belonging' is a prevalent theme in the students' accounts of their experience of studying mathematics at university. I will first present a typology of learner identities which shows the extent of marginalization in the group as they describe a mathematical knowledge that 'belongs elsewhere' and will never be theirs to access or make their own. Most of the students fall into a category of alignment to mathematics procedures which they participate in but do not contribute to. Some display imagination but risk becoming overwhelmed by their own viewpoint, failing to recognize that it is possible to stand back and position themselves in relation to the practice of mathematics. Only one student described herself in terms which fit the label of a 'legitimate peripheral participant' who, while still a novice, is nevertheless able to make constructive connections in mathematics and to act as a negotiator in the mathematics community. I shall first examine each mode of belonging, and then move on to discuss how the mix of modes positions individuals in relation to the practice of mathematics. I begin with alignment, as the most visible and most easily identified mode in the group.

### *5.1 Alignment*

While alignment in its positive sense describes a common agreed systems of rules, values or standards through which we can communicate within the practice and through which we can belong to the practice, systems which we do not own and cannot contribute to are no more than rule-bounded situations in which we participate only as rule-followers, not rule-makers. Thus an identity of pure alignment is experienced as a lack of control or understanding, as blind recipe following. This is a familiar identity in mathematics learners and remains prevalent even in undergraduate students<sup>2</sup>.

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<sup>2</sup> While it might be objected that this is the norm for mathematics students who are still learning the building block skills of the discipline, a number of mathematics educators, notably Maher (2005) and Burton (1999a) would argue that this is not a necessary situation at all, and that a participatory mathematics is possible even at primary school levels.

A number of students described their mathematics activities as blind rule following. They varied in terms of whether they experienced this as a source of irritation or were accepting of the situation; such variation appeared to depend on other aspects of their identities, notably (and perhaps not surprisingly) their views of their own abilities and of their likely future success in mathematics. For instance, Steve considers rule-following unproblematic, and even a bonus:

I like learning methods and, like, getting just one answer ... As a person I don't really like making decisions, I like everything laid out for me.

In this account, Steve does not portray marginalisation as we might expect. He is unworried by his predilection for clear-cut rules and does not intend to give up mathematics. Charlie equally sees no problem in rule-following without the support of intermediate steps:

If I've got the knowledge ... it's – like - learn and just memorise it. I hate the long way of doing something and then there's an easier way, I say you're never going to use it again so why did they teach it you in the first place?

Chris too is not bothered about understanding as long as there are rules to follow:

[If] I'm told so and so and so and so is this, then I won't go and read and try and understand why, I just remember the result ... I just accept what people say ...

A very different feeling about rules is described by Sue, however, who experiences mathematics as confusing and pointless. In her view, 'there doesn't seem to be any sort of reason ... in maths it seems they change the rules when they want'. Her irritation and frustration with the situation and her perceived role in it differentiates her from Steve, Chris and Charlie; while she experiences alignment as not belonging, they appear to experience it as belonging. Pete on the other hand falls in between these two positions as he describes himself as both 'good and bad' at different aspects of mathematics:

I seem to score well on tests, I do manage to get the mechanical bits, I don't, I'm not very good at proof, or understanding necessarily but I can learn things and how to do them and apply them but... [I'm not very good at] trying to understand it or ... just thinking about it and coming up with ideas in it.

A strong mode of belonging in terms of alignment inevitably emphasises getting 'right answers', over and above understanding. Although Sue, as we shall see, does not prioritise right answers, a number of students in the group did just this, relegating understanding to a lesser priority.

Thus Richard, who was very focused on his test results, liked mathematics because he could do it

and get it right. He has a clear preference for a subject which he perceives as having right and wrong answers which are given by the rules, and are outwith the realm of opinion or debate:

I don't care as long as I can do it. ... What I like about it [is] the fact that it gives you a right answer, if there's a definite answer, I'll be alright. .... There's a right and wrong in maths ... there's nothing that's open to the teacher's opinion ...

While he continues to get right answers, Richard is unconcerned; however, his tolerance for failure to get the right answers is minimal:

If I was struggling I'd drop it. I was alright at English but as soon as my grades started going down I dropped it. I just don't enjoy doing something I'm not good at. I have to be the best.

I shall explore how Richard can maintain this position below.

## *5.2 Imagination*

Imagination enables reflection on one's position within a practice and the perception of new patterns and the exploration of a practice and a new identity. Some of the students willingly reflected on what they were doing as students of mathematics, and considered explicitly how their approach helped them, often with reference to their own particular learning styles and experiences. Larry, for example, reflected on his success in maths:

Maths is based on a set of facts which you can follow through without having to rely on other things, you could use past experience. You could apply [basic rules] like if you know a method - a method that makes sense - you can combine that to get something else.

Here, Larry expresses an identity of being in control of learning mathematics. Debbie, while not understanding as well as Larry appears to do, enjoys the exploration of mathematics:

It's weird because even though I didn't really understand it - it took me a while to get to understand certain things - I did sort of feel to myself "I think I'm going to like this". You know, "I like the concept of it", you know, "I like proof, I think I'm going to be all right with that".

The negative trade-off of imagination, however, is the perception that, far from being an adventure, non-participation is a question of being out of control and without the necessary tools. Imagination here takes a stereotypical and somewhat subjective view. This is illustrated by Carol's account, in which she describes learning mathematics in terms of 'them' and 'us',

particularly when it comes to pure mathematics, which, she believes, does not allow her to express her own point of view:

I always wonder about maths, because I'm not really the kind of person that just accepts things, I always like to see the proof of it all and they just reel off all this stuff - "And this is how you do this" - and I'm, "Well, why?" ... Calculus: different styles of integration - do they explain why? No - "they just are". Which is useful (sarcastically) ... Probability and stats you can do more hands on, you can do more work yourself, you can have your own data you can do your own thing.

As we have seen, imagination resists blind alignment, but in Carol's case her adherence to her own viewpoint does not help. In particular, it prevents her from taking a part in the negotiation of meaning and a consequent ownership of knowledge, as I shall show below.

### 5.3 Engagement

It is by definition difficult to identify engagement in learner accounts - engagement is, arguably, the hallmark of the expert: in Wenger's model it epitomizes the state of the expert practitioner with tacit knowledge and deeply-held values and assumptions. However, we can perhaps see engagement in the sense of an identity of *potential* participation - what Lave and Wenger (1992) would call legitimate peripheral participation. This identity is evident in Sarah's account alone when she describes mathematical activity which is not a prescribed part of 'homework'. While she describes a preference for the security of being told what to do by tutors, she also finds herself looking for patterns and exploring them:

I find it a lot easier for them to say "this is what you are going to do, and this is how it's done", so in a way I am not very creative in my maths, but in a way I am as well, because sometimes I'm working and I think, "Oh maybe this could work", and I get all excited and it usually doesn't work but still I am thinking about it ... Sometimes, I might see, like, a connection between some things and I will think, "Oh maybe this would work and then maybe I would be able to prove that, and this, and the other".

Accounts such as Sarah's are rare. Notice the contrast between her attitude to her tutors and Carol's, which is marked by an adversarial stance; while Carol seems to perceive herself as excluded, as wasting her time, Sarah sees herself as potentially included, and indeed acts as though she is included. Her attitude to mathematics is correspondingly different; she appreciates its aesthetic:

It is nice. And also at the end you have this nice thing and you have worked all through it.

## 6. Positioning identity within the modes of belonging model

While in the preceding analysis I have selected comments which illustrate single modes of belonging, Wenger's model suggests that individual identities can best be represented as mixes of the modes, loading perhaps more strongly on one than others, but nevertheless containing elements of two or three. While my discussion of Sue above illustrates an identity of not belonging in terms of her negative account of rule following, a more holistic reading of her interview shows a clear element of imagination: she reflects on her experience of learning mathematics, and attempts to make sense of it as part of her university experience, and to situate it in her own mathematics history and future. Although Sue described herself throughout her interview as confused about mathematics, her attempts to understand both mathematics itself and the merits and demerits of her particular approach to it suggest perhaps that she is less marginalised than some of her comments seem to suggest. Here she reflects on the difficulty of undergraduate mathematics, attempting to draw on resources, knowledge and experiences that she has developed elsewhere:

With physics and chemistry moving from GCSE to A-level, the things we accepted at GCSE were then explained at A-level ... we still used them at GCSE but we just had to accept that ... you need to know this now but you can't understand them yet. ....In maths ... maybe it's because I haven't studied the whole picture, I've just got this little bit, and with being told I've got to accept things, and I've just accepted things as I've gone along, and now I've got to a point where I can't just accept things. I need to understand things that I'm being told, but I've got to accept a little bit more before I can start understanding.... Maybe if I carry on doing maths it might click again.

Debbie describes a similar resolve:

At first I was like "I don't understand" but I sort of thought to myself, "No, you know ... young children learn the ABC and don't question why C comes after B or anything like that, they just learn it". And I think I'm just gonna have to learn it [laughs] just, you know, have faith that I'll understand it eventually.

Unlike Carol, Sue and Debbie accept the apparent inconsistency or opacity of mathematics rules, assuming that they do make sense if only they can stand back and take in the wider picture. As yet unbeaten by the challenge of confusion, they display imagination in the sense that they are able to 'accept non-participation as an adventure' (Wenger, 1998: 185). In the remainder of this paper I explore how individual student identities come to display a particular mix of modes of belonging by examining the influence of institutional structures, practices and cultures on

identity formation. We can then begin to understand what constitutes a functional learner identity in the undergraduate mathematics community of practice.

### *6.1 The influence of fixed ability beliefs*

While Sue's account shows how a negative alignment experience can be offset by imagination, she nevertheless hovers on the threshold of a negative mathematics identity. Even in this undergraduate group – all of them holding good A-level or access results - identities are fragile. In large part this fragility is due to almost universal fixed ability beliefs which are perpetuated by the pedagogic practices that surround them. Thus Carol, in spite of her robust and critical outlook on mathematics teaching, puts her non-participation down to perceived deficiencies in herself; her beliefs about ability and the nature of mathematics itself all militate to build a self-excluding identity:

I don't know whether I've got to the stage where I think it's too difficult or I'm not bothered any more or if I don't really see the point of doing it any more. ... I think with maths, you're good at it or you're not particularly good at it ... you can struggle for years and years to understand maths and never grasp the concept, I think it is an all or nothing subject.

Ultimately, Carol subscribes to the idea that 'you can either do it or you can't'. Despite her rather more sophisticated and imaginative recognition that mathematics is about making connections, Diane also subscribes to the idea that successful students have a built-in overview of mathematics which enables them to solve novel problems:

I think that they can bring all the bits of maths that they've already done together whereas I think I need someone to say 'You have to take this from here and this from here and put them together to work out the answer to this one' ..... I think people who are good at maths can recognise that already and use the information that they've already got....

She invokes brain functions in mathematics ability when asked whether her mathematics performance could improve:

I could be taught to do maths but I don't think I could be taught to be good at maths. I think that's just something about the way the brain works or something.

Pete also believes in a biological basis for being good at mathematics, claiming that good students 'have some innate ability'.

We have already seen that Sarah's view is that she can learn from her mistakes; she stands out from the other students in her claim that hard work can reap benefits in terms of developing the mathematical way of seeing that Diane talks about but does not believe she can develop:

*Do you think that you can improve as a mathematician?* Yes, I think I could ... I definitely think I could put more effort in and ... go through and look at all the different examples and what happened in those examples and by doing that you learn and you learn to be able to see what is going to happen.

Nevertheless Sarah still invokes the idea of an uncoached mathematical 'talent' which echoes Diane's, and she contradicts her claims about hard work by giving voice to another dominant belief, that really good mathematicians never fail and don't even have to try:

I think some people can and some people can't .... [They] usually don't do much work at all ... they leave it to the last minute and they just do it and then they get full marks ... I am good at maths compared to most people but compared to them I am awful because ... they just have the mind for it, they can just see.

Debbie also refers to the companion belief that good students are fast workers:

You know, some people ... you get the impression that they don't really even have to think much. ... I don't think that my brain is as clued up as some of these that obviously can just do it.

The prevalence of such beliefs in these students' accounts alongside indications of imagination and engagement suggests a reason why students such as Debbie, Diane, Carol and Sue struggle to maintain a positive mathematics identity despite their apparently more participatory trajectory into the mathematics community. While Diane, for example, recognises explicitly the need to make connections in mathematics, the discourse of fixed ability, performance and speed of understanding as all-important has a detrimental influence on her identity. Sue interprets her need to understand as problematic, while Carol believes that she has reached her limit. Even Sarah describes herself as 'awful'. Looking closer at what these students say about the institutional structures and practices that they are part of shows how these continue to support the notion of fixed ability, thus undermining potential participation in mathematics and creating identity mixes which are *experienced as* marginalised. I explore these issues further in the next section.

## 7. The role of institutional structures and practices

Identities of non-participation in mathematics have important consequences. As the case studies here illustrate, these students experience mathematics as something 'done to them' rather than 'done by them'; they do not share in the ownership of meaning, let alone meaning making – they are excluded from that vital aspect of participation which Wenger identifies: negotiation. Engagement in a practice entails, as we have seen, an identity which includes the role of legitimate negotiator of meaning - those who participate fully in a practice are part of the process of development of ideas and meanings, and in this sense have ownership of meaning. We can extend this idea to include those who identify themselves and are identified by experts in the practice as legitimate peripheral participators - their ideas and contributions are treated as valid, to be taken seriously, to be built upon. As the case studies show, however, the majority of the students did not perceive themselves as potential negotiators of, or owners of, meaning. While, as noted above, it might be argued that undergraduates cannot expect to find themselves in this position anyway (a contestable notion given the work of writers such as Rogers (1995)), the important issue here is how undergraduates experience and make sense of this situation, and how this influences their self-perception and choices.

### *7.1 Experiencing classroom practices, gender and identity*

A number of the students perceived mathematics as non-negotiable (see also Solomon, in press), particularly pure mathematics, which was presented as a finished product, as a set of rules and strategies to be learned, not constructed. The net result of this teaching strategy was that pure mathematics was generally perceived as 'hard' and - more importantly - as a subject which they could not contribute to or be creative in. Carol expressed her dissatisfaction with this, comparing mathematics adversely with environmental science::

we're not going to discover anything new to do with pure maths. There's very little new experiments, new theories to work on.... You can't feel like a mathematician until you've learned quite a lot of stuff. [In environmental science] you're asked what you think about things.

Diane made a similar comparison between mathematics and geography:

In geography they just want to see that you've understood the question and see if you can bring your opinion into it. Whereas maths it's to see if you've understood. Full stop.

Of course, understanding is not necessarily conveyed by 'right answers'. Sue expressed bewilderment as she described getting answers but not owning the knowledge:

[It's] very frustrating, because you know you know how to do it, it's just the problems are so much more complex and they sort of go in more, I don't know, just things from nowhere, and you do get the answer in the end but you just don't know.

Diane's report of mathematics classes suggests confusion and isolation as she compares herself to the 'good' students who, as we have already seen, are fast workers:

They seem to know exactly what to do and they're just integrating and differentiating all over the place and I have to wait for the lecturer to do it. That's why I think I'm not good at maths.

Why do students such as Richard seem to be happy with their apparent alignment, and why is Sarah's evident engagement tempered with an identity of marginalisation? In this study, gender appears to play a large part in how students perceive their place in the undergraduate community of practice, in ways which we might not have predicted. Richard, Steve, Chris and Charlie experience positively the atmosphere of reward for alignment rather than engagement, and they feel correspondingly at home with mathematics as it is taught in this university in large, anonymous groups. Girls and women are frequently reported as experiencing such a teaching style as negative however (Becker, 1995; Willis, 1995) and the presentation of mathematics as a finished body of knowledge dealt with by mathematicians who never stumble down a blind alley is reported to be particularly disempowering for women (Rogers, 1995; Burton, 1995). The women in the study emphasised how much they wanted to understand, and their accounts were dominated by a sense of constant danger of feeling out of their depth - ownership is important to them but always threatens to be unattainable. Thus, while Richard says that ...

I think I'm the kind of person who should care about understanding but I don't ... I am competitive ... getting the right answer is more important ... I understand well enough to carry on.

.... Diane wistfully remembers her school days of small group support for understanding in an account which is reminiscent of Maher's (2005) work on proof with high school students:

In my A-Level ... we'd all work together to get the same answer and I think that really helped because we were teaching each other which would help us to understand. ... Because each of us understood different parts of it we were like, 'No, no, you're wrong, you're wrong', and say, 'Well explain yourself then'. ... I think it really helped me get through A-Level because you learn from each other as well ...

While the men rarely raised issues of teaching or group dynamics, the women were very likely to volunteer their appreciation of the value of working in a group, partly because the group lends a back-handed reassurance that they are not alone in not understanding. Carol described why she informally sought out other students when she was stuck, highlighting at the same time the lack of discussion in class:

I think it's just reassurance that you're not completely stupid because you can't do it, and just bouncing ideas off another person is better than sitting in your room attempting a question 50 times because you don't know how to do it. .... It's easier to talk amongst yourselves [outside of lessons] whereas in a tutorial you kind of feel under pressure just to not say anything in case it's the wrong answer.

Diane in particular makes a number of comments about the need to make and discuss connections in mathematics; her belief that she is unable to do this causes a major loss of confidence. Rather than supporting a participant identity, however, her epistemic insight into the role of connections causes her to feel increasingly inadequate and marginalized, not the reverse. Why should this be? It appears that the structure of mathematics learning as she is currently experiencing it disallows the making of connections - there is no time to do so and the reward system is not geared to fostering the kind of connection-making that Diane wants to do. In terms of this analysis, the community does not enable legitimate peripheral participation. Rather, it marginalizes learners who seek to participate beyond a focus on correct answers, causing them to doubt their ability. Diane, in the many comments in which she compares herself adversely with those who are 'good at maths', says that the 'good' ones are the confident ones, and they are usually male:

[They are] usually men .....they're getting too big headed and they know 'I can do this' .... They're all smug and they sit there and they're filling in the answers and then they sit back and sort of look over at what the other guy who's sitting next to them... like, 'Huh, you've done it wrong there' ..... Some of them are just really confident that they can do it and then they do it and they're really good.

## **8. Conclusion: Excluding practices and identities of exclusion**

What generates identities of non-participation and/or marginalization? Much research indicates that mathematics teaching is frequently excluding, and that it treats many students as powerless and unimportant 'outsiders', permanently marginalizing many (Boaler, 1997, 2002; Burton, 1999a; Fennema & Romberg, 1999). This same research indicates that mathematics can only be

made accessible to all in a participatory pedagogy which encourages exploration, negotiation and ownership of knowledge. Encouraging students to develop identities of participation in which they engage in the production and validation of mathematical knowledge, practice proofs for themselves, appreciate the aims of mathematics and how it is used makes mathematics accessible to many more students than otherwise in the sense that they are given the means of gaining ownership of it.

However, the students in this study are successful students, having chosen to study mathematics at university level, and one might expect them to display identities of participation for this reason. The data indicate, though, that an identity of legitimate peripheral participant is rare in this group. Analyzing learner accounts in terms of modes of belonging enables us to see further complexities in how identities are differentially experienced which go some way to explaining this situation.

Identities of exclusion are most obviously voiced by the women in this study although they are less marginalized according to Wenger's model than the men. The connected approach which they seek, epitomized in Diane's quest for links and patterns and in Sarah's perception of the possibility of creativity and negotiation, is very necessary for successful participation at all levels and for all students (see for example Burton, 1999a; Fennema & Romberg, 1999), as well as at degree level (see Rogers, 1995) and research level (Burton, 1999b). But traditional teaching and assessment does not make this explicit, maintaining instead the appearance of support for a performance orientation of the kind demonstrated most clearly in Steve's and Richard's heavily aligned accounts. What distinguishes the students' accounts is that, for the time being anyway, Richard, Charlie, Chris and Steve – and to some extent Pete - are happy with this state of not belonging (and indeed do not express excluded identities as such), while Carol, Sue and Diane are not. Even Sarah, the most confident of the women, believes that some people 'just have the mind for it', and does not count herself among them. Richard, Charlie, Chris and Steve accept their state of strong alignment whereas Carol, Sue, Debbie, Sarah and Diane strive for imagination and engagement. To the extent that their experience of mathematics teaching and learning emphasizes speed and performance, the men in the study have the more functional

identities in the undergraduate community of practice. The women, on the other hand, face failure regularly as they strive to meet the twin criteria of speed *and* understanding.

Wenger's model thus provides a starting point for an exploration of identity in this community. Contrary to the expectations set up by the model, however, the position of promising novice represented by Sarah's account is not associated with a positive identity, while that of the heavily aligned and non-participating Richard does not bring with it a negatively experienced identity. The resolution of these contradictory findings is brought about by recognising the duality of practices within the same community with opposing rules of engagement, and consequently of differential experiences of identity within that community. Within the undergraduate community of practice, the dominant discourse of performance within which mathematics identities are constructed dictates the apparent functionality of particular identities.

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