Objectives

Adults Learning Mathematics (ALM) – An International Research Forum has been established since 1994 (see www.alm-online.net), with an annual conference and newsletters for members. ALM is an international research forum that brings together researchers and practitioners in adult mathematics/numeracy teaching and learning in order to promote the learning of mathematics by adults. Since 2000, ALM has been a Company Limited by Guarantee (No.3901346) and a National and Overseas Worldwide Charity under English and Welsh Law (No.1079462). Through the annual ALM conference proceedings and the work of individual members, an enormous contribution has been made to making available research and theories in a field which remains under-researched and under-theorized. In 2005, ALM launched an international journal dedicated to advancing the field of adult mathematics teaching and learning.

Adults Learning Mathematics – An International Journal is an international refereed journal that aims to provide a forum for the online publication of high quality research on the teaching and learning, knowledge and uses of numeracy/mathematics to adults at all levels in a variety of educational sectors. Submitted papers should normally be of interest to an international readership. Contributions focus on issues in the following areas:

- Research and theoretical perspectives in the area of adults learning mathematics/numeracy
- Debate on special issues in the area of adults learning mathematics/numeracy
- Practice: critical analysis of course materials and tasks, policy developments in curriculum and assessment, or data from large-scale tests, nationally and internationally.

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It is my pleasure to introduce this new issue of the Adults Learning Mathematics: An International Journal. We have collected a diverse number of articles in this issue. There are works on teachers’ identity, on students’ feelings towards mathematics, proposals to create spaces for mathematics literacy reading books, or critical reviews around international surveys, such PIAAC, or the importance to really be accurate when solving mathematical problems or tasks involving mathematical calculations. All in all, what it suggests to me is that mathematics is everywhere, as I said with some other colleagues many years ago (Turner, Varley, Simic & Díez-Palomar, 2009).

Numeracy (or mathematics literacy, as we discussed in ALM fourteen years ago in Strobl), means to be able to use mathematics critically, to solve situations in our live. It means going beyond the idea of learning (doing) mathematics because “it is what the teacher is asking me to do”, or because “it is on the textbook.” Actually, there is a great discussion internationally about how to teach mathematics, so it is not just a fact of memorization and solving standard sets of problems, but a way to really support people to become mathematically literate. The National Council of Teachers of Mathematics in USA is asking right now to comment on a new proposal called Catalyzing Change in High School Mathematics drawing on the idea of how to find ways to support youth to love mathematics beyond its school presentation, using it meaningfully, proficiently, critically and (I assume) avoiding the generation of adults hating (and failing) mathematics. USA authorities are looking for successful strategies to encourage STEM (Science, Technology, Engineering and Mathematics) careers, and since mathematics is “at the heart” of STEM subjects, the educationalists want to find a way to make the subjects attractive to young people.

The contributions by the articles included in this issue may help in finding a suitable answer to the challenge of making mathematics attractive. Ryan and Fitzmaurice, for instance, suggest that exploring everyday situations to discover the mathematics embedded in them is a strategy that produces less anxiety towards mathematics than classic school practices. However, the teaching context is probably not enough to entzauberung mathematik (used here to mean re-enjoy mathematics, the opposite of the idea of Entzauberung der Welt – disenchantment with the world theorized by Max Weber a hundred years ago). We also need teachers to act critically and support a learning environment in which individuals find [again] the joy of doing mathematics.

The first article is devoted to analysing the identity of teachers of mathematics in the further education (FE) sector in the U.K. Dalby presents a study with 39 teachers who believe that “being a teacher” means more than just “teaching the subject”. In their view, they also perform a type of a mentoring role with students (or learners). Dalby analyses the complexity of being a mathematics teacher within the field of further education drawing on the notion of “communities

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of practice.” The 39 teachers participating in the study reveal that they were good at mathematics (in primary and secondary school), but the kind of mathematics that they learnt is not enough to deal with the challenges in their workplace, that of teaching adult learners in FE. These teachers describe how their identity as teachers is influenced by critical incidents in their own lives and localised by their working situations. Dalby holds that mathematics teachers in FE do not have a “strong positive professional identity”, because according to them, they do many “other things” than just teaching mathematics. The author sees this situation as a concern, especially in terms of recruiting new mathematics teacher to work in FE. She asks for further research to find new ways to deal this situation.

The second article included in this issue is devoted to the analysis of PIAAC results. The authors outline their concerns about the limitations that the statistical instruments used by PIAAC (and other OECD surveys, namely ALL and IALS) may have when employed to report on the mathematical literacy (or numeracy) of adults. Indeed, they ask rhetorically “perhaps adult skills policy makers and most adult citizens are living in different worlds?” As readers may know, PIAAC is a worldwide survey on adult skills which includes looking at numeracy in a range of work-related, personal, social and community contexts along with more general education and training scenarios. Being numerate is one of the biggest concerns for many authorities and stakeholders working in adult education fields. It seems clear (or at least commonly agreed) that adults use mathematics in their everyday lives in many ways and in many contexts. It is said that mathematics is “all around”, and we can see it in a plethora of situations, most of them very far away from what we understand as “school contexts.” In fact, many adult learners participating in adult education institutions report that their “lack of schooling background” does not interfere with their everyday, numerate skills. On the contrary, they have learnt strategies to solve everyday problems using what we would call “a mathematics reasoning scheme” while being formally “illiterate” in terms of [school] mathematics. How is it possible? The authors discuss the fact that we need to really understand the idea of context of adults’ lives. This is important, since out-of-school contexts can be seen as containing embedded mathematics. The authors argue that many policy makers fail “to give the basic numerical information that any citizen would need in order to be able to make informed decisions.” They suggest that there is a “lack of opportunities” for adults to really use mathematics in a meaningful way and to take important decisions. The authors consider the notion of a numerate environment – a parallel to an existing notion of a literate environment. They propose concrete examples of such environments and discuss the demands, opportunities and supports for adults to exercise their (literacy and) numeracy skills.

In the third article, the authors discuss the readiness of a group of university students in a course in nursing numeracy. According to their data, more than three out of four students feel that they have adequate skills to deal with fractions, percentages, ratios, graphing, and problem-solving situations. However, when testing those skills, the data collected reveals that a significant percentage of them make mathematical errors. The authors note that in some cases, the underperformance on some questions is not considered significant by the students because overall “they passed the course”. The article is consistent with the concern that nursing practitioners could, through overconfidence, produce mistakes detrimental to the health of patients when employed in the real world. This affects not only people in hospitals, waiting to receive a professional care, but also to other end-users in other professional fields. Mathematics must be more than just a set of objects and propositions regulating the ways in which those objects relates one to each other. Mathematics offers a perspective on the world, a form of critical thinking which provides appropriate answers to questions from real life scenarios. This article helps us understand better the situation with student nurses.

In the fourth article Díez-Palomar introduces Mathematics Dialogic Gatherings as spaces for adult learners to discuss mathematics using classic books. Drawing on Dialogic Learning as a theoretical approach, the author explains how adults using egalitarian dialogue are able to explore and go beyond the books in their understanding of mathematics. Drawing on concepts such
exploratory talk conceived by Mercer, for example, the author argues that adults are able to share their own understanding regarding mathematical ideas, supporting each other to overcome the difficulties to fully appreciate the mathematical meaning embedded in the concepts. MLG come from the Dialogic Literary Gatherings created by Flecha (2000) in the late 1970s in an adult education institute in Barcelona. Dozens of persons who never went to the school before, shared classic readings such Kafka, Cervantes, Wilde, Woolf, etc., thanks to the opportunity to share pieces of them with the participants in the DLG. Using classics is a condition sine qua non, because these types of book are seen as “difficult”, they “contain important ideas and themes” and are considered “well-written”. Hence, using them as sources of literacy is a way to encourage the quality of the learning emerging from this type of space. The same applies for the MDG. Díez-Palomar narrates how adults use classic readings in mathematics to discuss the ideas raised in the texts. The author argues that such gatherings afford the opportunity for the body of mathematical knowledge to be available to everyone.

The last article is devoted to discussing mathematics anxiety. Ryan and Fitzmaurice use a mixed methods approach to report on the feelings towards mathematics from a cohort of individuals from Ireland. Mathematics anxiety has been a key topic in the field of adults’ mathematics learning. Being afraid of mathematics is a common sentiment that many adults report when talking about mathematics. Previous studies have noted that, in part, this feeling is the legacy of bad experiences with mathematics in school. Such learners report that they were labelled, that they were placed in a lower attainment group that were considered “dummies” and that they were “pointed out” by individuals. Such experiences have led to anxiety. The authors use an existing instrument to identify situations in which individuals feel more afraid about mathematics. The results suggest that people who are asked to show solutions on the board at the front of a mathematics class, or who are given a surprise mathematics test in a class, or who are asked a mathematics question in front of a class, develop fear and apprehension towards mathematics. In other words, exposing a person to an audience in a public space generates a situation involving a lack of security which, in turn, provokes fear and lowers self-esteem. The qualitative case studies presented by the authors confirm that analysis. On the contrary, when people use mathematics in real situations, to solve real problems (everyday problems), where mathematics is embedded in the situation (but no one would identify the situation as a “school mathematics situation”), then they do not identify anxiety and fear with mathematics, but the opposite: they feel safe and comfortable.

Putting all the contributions from these articles together, it seems that we can be optimistic about finding a successful approach to re-enjoy mathematics. Looking around us; using everyday contexts and situations to experience mathematics; valuing what other people know about mathematics; re-designing our current instruments used to study people numeracy skills: these aspects seems to be good ways to approach that huge challenge, which is entzauberung mathematik.

References
The Professional Identity of Mathematics Teachers in Further Education

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Abstract
Professional identities may be viewed as narrative constructions in social situations but personal experiences and beliefs are fundamental influences in their development. Within Further Education colleges in England, mathematics teachers are typically expected to fulfil multiple roles, teaching a wide range of curricula and age groups, and this brings additional complexity to their professional identities. In this study, questionnaires and interviews with mathematics teachers in three Further Education colleges are used to examine their roles and professional identities. The findings show how teachers' personal experiences of mathematics, in formal education and the workplace, influence their beliefs and are linked to their narrative and working identities. These teachers enact complex and varied roles but develop a 'leading professional identity' that can be linked to significant critical events in the past.

Key words: professional identities, personal experiences, beliefs, workplace

Introduction
The division of upper secondary education in England at age 16 years into distinct academic and vocational pathways has led to the development of distinctly different types of curricula and assessment for post-16 students. Over the last two decades a series of different post-16 mathematics qualifications have been used to enhance the mathematical skills of vocational students, with a focus on skills for life and work, but with titles involving the terms numeracy, skills or mathematics (e.g. Key Skills, Adult Numeracy, functional mathematics). In a recent review of the mathematics workforce in Further Education (Hayward & Homer, 2015) teachers identified themselves as being either numeracy or mathematics teachers, even though the Adult Numeracy qualification is no longer being taught.

This suggests that there are at least two distinct types of professional identity amongst teachers in Further Education who might all be considered broadly as teaching some form of mathematics. Whether this distinction arises from their role, in terms of the subjects or age group that they teach, or a personal affinity influenced by other sociocultural factors, it is clear that the workforce does not have a single professional identity. Furthermore, Hayward and Homer (2015) conclude that there is insufficient reliable data, which leaves questions unanswered about the functions carried out by these teachers and their professional development needs.

The aim of this paper is to explore both the roles carried out and the professional identities constructed by a sample of mathematics and numeracy teachers from three general Further Education colleges, in order to gain a better insight into the expectations placed on them in the workplace and their professional development needs. The research will also explore the backgrounds of those teaching mathematics or numeracy in Further Education and indicate key areas to be considered in recruitment and pre-service teacher education. In view of the shortage of mathematics teachers in England, particularly in Further Education, the study provides some...
valuable insight to inform the development of effective policies for future recruitment and training. The research seeks to address the following questions:

- What roles are carried out by mathematics and numeracy teachers in Further Education colleges?
- How can the professional identities of these teachers be described?
- What are the implications for the recruitment, training and professional development of mathematics teachers in Further Education?

**Background**

The professional identity and training of teachers generally in Further Education colleges has been a problematic issue that successive governments have sought to address in different ways (Fletcher, Lucas, Crowther, & Taubman, 2015). Historically, vocational teachers were occupational experts who shared their knowledge with trainees and professional training as a teacher has often been viewed as secondary or even unnecessary, by practitioners and managers. The introduction of national occupational standards for teachers in 1990 may have helped shape ideas regarding the definition of a professional identity for teachers in Further Education at the time but subsequent redefinitions of professional standards (2006) and eventual de-regulation (2012) may have served to confuse rather than consolidate the emerging notion of a professional educator in this sector of education. The diversity of education within Further Education colleges (e.g. vocational, academic and adult) further confuses the roles and identities of teachers who work in this area.

There is some agreement that vocational teachers in Further Education colleges fulfill a ‘dual’ identity (Peel, 2005) as both professional occupational experts and as teachers. Whether those who teach mathematics and/or numeracy in Further Education can assume the same type of dual identity is questionable. A similar ‘dual’ identity would involve being a professional expert mathematician and a teacher but entry requirements to teaching mathematics or numeracy in Further Education do not necessarily include qualifications consistent with having attained an ‘expert’ level of mathematics. Current de-regulation leaves decisions largely to individual colleges and therefore variation can be expected between Further Education institutions, even in the presence of national recommendations.

For those teaching on courses that might be broadly considered as mathematics, there is the added complication of this distinction between mathematics and numeracy. Although previously numeracy had been associated with simple numerical calculations and routine processes, as a subset of mathematics, Cockcroft (1982) refers to a wider set of skills involving applications to life and work. This suggests that numeracy is concerned with the use of mathematics rather than a simplified type of mathematics. The introduction of the Adult Numeracy Core Curriculum in 2001 led to new adult numeracy qualifications and contributed to a distinction between being a numeracy or mathematics teacher on the basis of whether the teacher’s timetable focused on teaching adults (Adult Numeracy) or younger students (Key Skills). Teachers might teach, however, across age groups and, with the replacement of Key Skills and Adult Numeracy with functional mathematics, one might expect such distinctions to disappear.

The evidence within the recent workforce report (Hayward and Homer, 2015) suggests though that teachers still retain a strong identity with either mathematics or numeracy. Considering that these teachers may have combined age groups in their classes, or mixed timetables of classes for different age groups and qualifications, the distinction is difficult to explain.

In the current situation, with new routes into teaching mathematics or numeracy in Further Education, such as the re-training of teachers of other subjects to teach mathematics, clear identities may be difficult to establish. There are also a wide range of perspectives on the meaning of identity that affect the way in which professional identity is researched. Therefore, before
exploring the roles and professional identities of a sample of teachers from three Further Education colleges, some consideration needs to be given to the theoretical view of professional identity that will be used the study.

**Professional Identity**

Before approaching the notion of professional identity, it seems necessary to establish a position on the meaning of the term ‘identity’ since this affects the way in which the research is conducted. Use of identity as a concept in educational research has become more prominent since the socio-cultural turn, offering a useful bridge to explain how “collective discourses shape personal worlds and how individual voices combine into the voice of a community” (Sfard & Prusak, 2005, p.15). The concept is used however across many traditions (e.g. anthropology, psychology and sociology) and the meanings attributed are not the same. As Sfard and Prusack (2005) explain, there is a need to determine an effective and theoretically sound operational definition.

There is some agreement that identities are constructed by individuals within discourse (Holland, 2001) but one of the contentious issues lies with the assumption that this is only indicative of a ‘true’ identity that resides with the individual. Whether this personal identity remains a stable trait or changes over time is a secondary problem resulting from the first assumption. From this perspective the researcher only gains a glimpse of a personal hidden identity and uses the indications from an observed or co-constructed discourse to develop their own perception of what this ‘true’ identity may be. The presence of any stable trait however is inconsistent with the socio-cultural position in which social interactions are seen as shaping identity. In this tradition the narrative is a place where identity is actually constructed and therefore it is socially situated, ever changing and created by the individual for the situation. This leads to a position where the researcher can use the narrative to construct a more reliable analysis of an identity with the understanding that this is uniquely created within the narrative, by the individual, for the situation. In an interview situation it is therefore an identity constructed for the researcher but, as such, has authenticity and credibility when defined in this way.

Professional identity might broadly be perceived as the part of identity that a person constructs in relation to their profession or occupation. Brockmann (2012) uses this notion of an occupational identity to explain how students in vocational areas adopt particular behaviours. This is consistent with the occupational aspect of the ‘dual professionalism’ of vocational teachers who are seen as occupational experts but also as professional teachers. How this connects to the professional identity of mathematics or numeracy teachers though is not clear since there is no single occupational body to which these teachers would be connected, unless they classify themselves as mathematicians. Their professional identity seems to be more closely related to their function as a professional teacher than to an occupational body.

Day, Sammons and Stobart (2007), in their study of teachers’ lives and work propose three areas of influence on identity: professional, local and personal. From this viewpoint there is a socially accepted general view of the profession to which the individual belongs, a positioning within the department or local (institutional) situation and then their personal individual life outside the workplace. For the purposes of this study this provides a useful outline framework. In each of these categories we will consider how the individual functions as part of a social community, which may or may not be an active community of practice (Lave & Wenger, 1991; Wenger, 1999).

Communities of practice would normally have a domain of operation, a shared interest and a commitment to each other that distinguishes them from simply an interest group (Wenger, 1999). Teams of mathematics or numeracy teachers may well form a community of practice within their college but also identify themselves with a wider community such as the body of mathematics teachers in Further Education. For the purposes of this research, how teachers position themselves in relation to these communities at different levels (local and national) is of particular interest.
This may include how they see themselves in relation to common perceptions of mathematics teachers in society, or how they relate themselves to the specific department in which they teach. Within a local community of practice, an individual may describe themselves as an expert with a central position, or a peripheral member such as a new teacher who is still learning their ‘craft’ and therefore occupies a position of legitimate peripheral participation (Lave & Wenger, 1991; Wenger, 1999). Alternatively, Wenger (1999) suggests that marginalisation may occur, when access to becoming an expert is denied. An individual may also describe their positioning in relation to several different communities of practice to which they have some sense of belonging and this may include more than one within the same workplace.

For the purposes of this research, there needs to be a consideration of how this positioning within any community of practice can be obtained. Taking the approach that identity is constructed within the narrative means that teachers own descriptive accounts are essential. There is a common theme in much of the literature that suggests key events are influential in shaping identity and these will be important to capture. Black, Williams, Hernandez-Martinez, Davis, Pampaka & Wake (2010) refer to these as ‘leading activities’ that have a significant effect on shaping ‘leading identities’. Such events are recounted by the individual in relation to a personal association with the focus of the discourse and thereby provide connections within a narrative identity that are valuable in sense-making for the researcher. The research approach will therefore be based on a sociocultural view that considers professional identity as a personal concept related to past events but constructed for the researcher in the interview situation. This may incorporate personal beliefs, values and emotions but includes what they think and do into a sense of who they are (Grootenboer & Ballantyne, 2010).

**Methodology**

The research aims to explore aspects of both the roles and professional identities of a sample of teachers in Further Education who are all teaching at least some functional mathematics courses, although they may also teach other classes. There are two main sources of data that inform the study.

Firstly, with respect to the roles of individuals, quantitative data from questionnaires are the primary data source. Questionnaires were used to explore teachers’ roles through questions about their highest mathematics qualifications, number of years teaching, number of years in current institution and type of contract. This was completed by functional mathematics teachers (39) in three FE colleges on a voluntary basis. An overall return rate of 50% was achieved although this rate was not consistent across the colleges. The questionnaire data presents a summary of backgrounds and qualifications for a sample of mathematics teachers in these colleges but has some limitations due to the sample selection method and sample size. Its value therefore lies in indicating a possible range of roles rather than the typical role carried out by mathematics teachers in Further Education.

Secondly, semi-structured interviews were used to examine some of the roles, functions and professional identities of these teachers in more detail. A sample of twenty teachers was selected from those who had submitted a questionnaire. This sample represented the range of backgrounds, roles, ages and gender evident from the questionnaire returns but allowed the researcher to explore issues from the questionnaires in more depth. Using the theoretical position described earlier meant that capturing individual narratives in these interviews was important. The teachers were therefore asked to:

1. Briefly describe their backgrounds and explain how they came to be a functional mathematics teacher;
2. Explain their relationship with mathematics;
3. Describe their teaching role in the college, including their status and relationships with vocational teachers.

Interviews were audio-recorded, transcribed and initially coded using the framework:

- Critical personal experiences in identity formation;
- Narrative identity (personal and professional aspects, including identity as a teacher, vocational expert or mathematician);
- Working identity (identity within the functional mathematics community of practice).

Particular attention was given to identifying significant events in individual narratives, any links to aspects of professional identity and indications of positioning within communities at local and national level. Further analysis was then conducted to explore connections between personal experiences and aspects of narrative identity.

**Results**

The relevant results from the questionnaire (which also covered wider aspects of teaching) are first summarised in this section before examining the interview data and further analysis. There were 39 respondents in total: 22 male; 17 female. Most of these were employed on full-time contracts (28) and the majority were permanent contracts (33) although there were some temporary staff (4) or ones on mixed contracts (2). The average (mean) length of service was 10.7 years but there was a wide range of experience amongst these teachers (1-30 years). There was a similar range in the number of years teaching at their current institution (1-30 years) but an average length of time of 7.2 years. A high proportion of teachers (21) had only ever taught in their current college.

<table>
<thead>
<tr>
<th>Qualification</th>
<th>None</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
<th>Level 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest mathematics qualification achieved at school</td>
<td>2</td>
<td>21</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest mathematics qualification achieved since school</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>13</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

For the purposes of this paper the actual qualifications stated by teachers have been grouped by the levels of the Qualifications and Credit Framework used in England. Level 2 corresponds to the level expected by age 16 years (GCSE level) and Level 3 to the level of academic qualification achieved at age 18 years (A level) for students who specialize in mathematics. Level 6 corresponds to an Honours degree and Level 7 to Masters level.

There is a wide variation in the highest mathematical attainment of these teachers at school and in qualifications taken since school. The data suggest that the majority of teachers did not specialise in mathematics in school (23) and that almost half (17) do not hold a mathematics qualification above Level 3. The qualifications achieved after leaving school range from GCSE mathematics to Masters level qualifications in STEM subjects (with substantial mathematical content). There is also evidence from the actual qualifications stated that the disciplinary backgrounds of teachers vary widely across mathematics, science and the social sciences. All of
these teachers did however have a formal teaching qualification but these varied between post-graduate, degree level and lower level qualifications.

Table 2  
*Table showing other subjects taught by functional mathematics teachers.*

<table>
<thead>
<tr>
<th>Vocational skills (English or IT)</th>
<th>Functional skills</th>
<th>GCSE Maths</th>
<th>A level Maths</th>
<th>Other Maths</th>
<th>Numeracy</th>
<th>Key Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>18</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

There was wide variation in the backgrounds of these teachers but also in the other subjects that they taught. Almost half the teachers also taught another functional skill (either English, ICT or both) and more taught on vocational programmes than on GCSE and A level courses. Of the 39 teachers, only five were exclusively teaching mathematics/numeracy subjects (i.e. GCSE Mathematics, A-level Mathematics, Key Skills Application of Number, Functional Skills Mathematics or other mathematics such as specialist modules for Engineering students). Although teachers were given a free choice of subjects only one stated that they taught numeracy. This suggests that the sample is not directly comparable to the wider survey conducted by Hayward and Homer (2015) but does indicate the range of variation in mathematics or numeracy teachers’ backgrounds and roles within even a small group of colleges.

For the twenty teachers who were interviewed, there was further evidence of very varied backgrounds and also routes into teaching mathematics. By using the framework described earlier and then more detailed analysis with further coding, some key themes emerged. These will be illustrated by summaries of the basic analysis for two teachers with contrasting narratives, to show the type of data extracted from these interviews.

*Example 1: Lynne*

Critical personal experiences:
- Had a career in retail management, so believes she understands how mathematics is used in the workplace;
- Loved mathematics at school but did not do well with A level mathematics, so does not see herself as a mathematician.

Narrative identity:
- States that she is not a ‘maths guru’ i.e. high level mathematician;
- States she is not a ‘geek’;
- Believes she relates well to students;
- Sees herself as a functional expert rather than a mathematician, i.e. views herself an expert in using mathematics and making it relevant.

Working identity:
- Has a lead role as a functional expert in the team;
- Acts as a guide to others;
- Sees herself as distinct from mathematicians within the team;
- Believes she needs to build connections to the vocational teachers to enhance the relevance of the functional mathematics she teaches.
Example 2: Ian

Critical personal experiences:

- Recognised as having dyslexia at school, so has leaned towards mathematics and science;
- Both parents were teachers but insisted he should work before teaching so he would better understand people who were less mathematical;
- Had early involvement with functional mathematics qualifications externally, so understands the philosophy behind the qualification.

Narrative identity:

- Sees himself as a mathematician (high level);
- Believes functional mathematics is consistent with his identity since it emphasises mathematical thinking rather than fluency with routine processes;
- Believes he is not successful with lower level mathematics students.

Working identity:

- Teaches across different levels of mathematics, including higher mathematics;
- Has a role as a lead practitioner for functional mathematics due to his external involvement;
- Teacher educator so trains other teachers within the college.

Within these two examples there are indications of the main themes that emerged from the full set of interviews. As suggested by Sfard and Prusak (2005) the critical experiences highlighted by teachers in their accounts of how they came to be a functional mathematics teacher were strongly linked to their narrative identities and positioning within their working situations. The coherence between these critical personal experiences, narrative identities and working identities suggests aspects of a ‘leading professional identity’ similar to the concept of a ‘leading identity’ used by (Black et al., 2010). Although there is coherence, the data still suggests such professional identities are multi-faceted and highly variable across this sample of teachers.

The interviews also provided data on the entry routes of teachers to their positions as functional mathematics teachers in Further Education colleges. These were diverse, with a common theme of mathematics teaching in Further Education being a career change after other employment. This was often not planned in advance but followed from casual conversations and encounters with friends or acquaintances who suggested this as a suitable path. Some teachers were trainers or assessors before entering teaching, or had started as part-time temporary staff before progressing to more substantial contracts. Only one of the twenty teachers interviewed had left formal education with the intention of becoming a mathematics teacher as their first choice of career.

For some of these teachers, the decision to focus on mathematics as their main subject was a personal choice based on a love of the subject or ability, but for others it was a pragmatic choice based on the assumption that there would be job security as a result of a continuing national need for more mathematics teachers. The following section of summary data from the questionnaire indicates the extent to which teachers liked mathematics and believed it to be useful.
Table 3
*A table to show teachers’ responses to mathematics.*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maths is a subject I liked at primary school</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Maths is a subject I liked at secondary school</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Maths is a subject I like today</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>The maths I learned at school has been useful in my personal life</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>11</td>
<td>15</td>
</tr>
</tbody>
</table>

There is evidence that most of these teachers now liked mathematics and believed it had been useful. This is not unexpected, since these teachers have chosen to be mathematics teachers but, despite positive feelings and beliefs from the majority, there are some mathematics teachers who are less convinced. Notably, early experiences of mathematics were not all positive and changes have taken place over time. Many of these teachers were actually teaching several subjects and there were indications in their interviews that decisions about what subjects appeared on their timetable were often made by managers. The subjects they taught, therefore, did not always match the specialist training, skills or preferences of the individual.

**Implications and conclusions**

The wide variety of subject combinations and levels of mathematics taught by this fairly small sample of teachers in just three Further Education colleges suggests that roles in the sector are very varied. This demands a flexibility and adaptability to different social situations, in addition to wide subject knowledge. Current provision for initial teacher education and professional development, which tends to focus on subject knowledge and general pedagogy, seems unlikely to adequately address the needs of teachers to adapt to such complex, multiple roles.

Multiple entry routes into teaching and the lack of compulsory pre-service training make it difficult to establish a recognised professional identity or status for mathematics teachers in Further Education. The public and political view in England seems to be that mathematics teachers in Further Education are an ill-defined and possibly inferior subset of mathematics teachers, since they only teach low-attaining and less academic students. This study suggests a need for a better definition of professional identity for these teachers in Further Education, particularly in terms of the multiple roles carried out and the skills expected. The tensions of ‘dual professionalism’ experienced by vocational teachers (Peel, 2005) were less evident for these teachers, who often identified themselves more strongly with being a Further Education teacher than with being a mathematician. Within their narratives, the teachers in the study generally provided coherent individual accounts of who they were (Grootenboer & Ballantyne, 2010) but there was no strong shared sense of professional identity, even for teachers within the same
college. In their individual narratives, they often constructed a ‘leading professional identity’ that was connected to critical experiences in the past but there was little evidence of a collective discourse (Sfard & Prusak, 2005) or of individual voices combining into the voice of a community.

The absence of strong positive professional identities at local and national level is a concern. An effective community of practice is dependent on having a shared vision and commitment (Wenger, 1999). It seems unlikely that existing local communities of mathematics teachers in Further Education will move forward in their professional practice without a clear shared understanding of their professional identity, since this determines what sort of ‘expert’ they are trying to become.

Entry routes for new teachers of mathematics in Further Education are difficult to categorise from the study due to the wide variation evidenced. A current shortage of mathematics teachers, particularly in Further Education may make it an attractive second career with some job security, despite the lack of parity with schools regarding pay and conditions in England. The difficulty lies in where to focus when recruiting new teachers into the profession when the existing workforce is so diverse and their professional identities are difficult to define. In the absence of strong positive national or local identities the sector seems likely to continue to struggle with the development of an effective recruitment strategy.

Strategies to recruit new mathematics teachers to work in Further Education have recently focused on high-achieving graduates in mathematics or science, due to perceptions that sound subject knowledge is essential. Although subject knowledge is undoubtedly important, it is worth noting that the teachers in this study often positioned themselves primarily as teachers in Further Education, relating to the Further Education community more strongly than to being a mathematics teacher. Furthermore, there was more frequent identification with being a functional mathematics teacher (who understood how mathematics was used in life and work) than with being a mathematician. This suggests the need to consider the suitability of new recruits for teaching contrasting curricula, as well as the context in which they are expected to work and the roles they need to fulfil.

This small-scale study indicates some important areas for consideration in the professional identities of mathematics teachers in Further Education in England but also highlights the need for a larger scale study of roles and identities. The findings suggest that mathematics teachers in Further Education need to be prepared to work flexibly, teach more than one subject, teach across levels and adapt their teaching to different curricula and age groups. This requires personal qualities and skills that go beyond subject knowledge and basic pedagogy. A wider and more detailed study of the roles and professional identities of mathematics teachers in Further Education is clearly needed to better inform strategies for the recruitment of teachers, their initial training and professional development, but this study provides some foundations from which further research could be developed.

References


Abstract

In the 2012 PIAAC Survey of Adult Skills of 23 industrialised countries, the UK (England & NI) scored below average on adult numeracy. Several recommendations focus on the need for (some) individuals in the population to undergo training. Yet, even in “high-performing countries” like the Netherlands, many adults (1.5M) score at or below PIAAC Level 1 (sometimes designated as “functionally innumerate”). The question arises as to how all of these people manage in important domains of their lives. In this article we aim to consider the context of the exercise of numeracy by adults, drawing on earlier research in mathematics education. We examine a recent conception of an adult’s ‘literate environment’ (EU HLG on Literacy, 2012), and extend this to reflect on the idea of an adult’s ‘numerate environment’. We consider the range of practices that particular adults may engage in, and the demands that these may make on the adult, the affordances the practices may offer; the latter include the opportunities, and the supports and / or barriers produced within these practices, and in cultures more generally, that may foster or impede an adult’s ongoing numerate development. We give examples of each of these aspects of adults’ numerate practices, and consider implications for the teaching, learning and development of numeracy.

Key words: numeracy, assessment, PIAAC, skills
Introduction

In the 2012 PIAAC Survey of Adult Skills of 23 industrialised countries, the UK (England & Northern Ireland) is one of ten countries which scored below average on Numeracy. (It scored above average on Adult Literacy and above average on “PSTRE” (“basic IT skills” or “digital literacy”).) The Numeracy results, in particular, were widely hailed in the media as “not good” (Yasukawa, Hamilton & Evans, 2016). Even in “high-performing countries” like the nearby Netherlands, many adults (1.5M, out of just over 11M aged 16-65) scored at or below PIAAC Level 1, and thus are seen as “functionally innumerate”. In spite of their different positions in the overall rankings, these two countries, and many others, appear to share a common policy problem, namely what is to be done about such apparently significant groups of adults?

Some of the remedies proposed focus on the lacks, or deficits, on the part of (at least some) adults in the population. On this view, the solution is training, mostly via formal learning such as in “basic skills courses” at college. However, we also know from sources such as the EU Adult Education Survey and PIAAC itself that adults who seem to have the most need are the least likely to engage in formal adult education courses.

We might ask: How do all these people manage in important domains of their lives? Perhaps they are more at ease than some policy makers allow (Grotlüschen et al., 2016)? This echoes earlier findings that respondents consistently self-rated their level on literacy and numeracy higher than they “should have”, given their scores on the previous OECD sponsored surveys, the International Adult Literacy Survey (IALS), and the Adult Literacy and Lifeskills Survey (ALL), as well as on national surveys like the Skills for Life assessments in the UK (e.g. Ekinsmyth & Bynner, 1994; Henningssen, 2006).

Perhaps adult skills policy makers and most adult citizens are living in different worlds?
How can we begin to characterise the worlds that most adults live in? We propose that an ecological perspective of the affordances and opportunities adults have for numeracy development may be fruitful (see for example Barton (2007) and van Lier (2000) for an ecological perspective on literacy, and on language learning).

Understanding the Contexts of Adults’ Lives

Ecological issues have been taken up in mathematics education research, in long-standing discussions aiming to understand the notion of context; see e.g. Bishop (1988); Evans (2000); Lave (1988); Lerman (2000); Nunes, Schliemann & Carraher (1993); Walkerdine (1988); and many others. Studies in adult literacy and adult numeracy have also contributed to this research base.

One major strand of these broadly “sociocultural” approaches considers the world of adults to be “constituted” (framed materially, conceptually and socially) by the practices the adults are engaged in (e.g. Evans, 2000). How can we know about these practices?

It would appear that we can approach these practices in two ways: top-down (“generalising”, Evans, Wedge & Yasukawa, 2013) or bottom-up (“grounded”). For top-down (“generalising”) analyses, we can analyse hypothetical sets of practices that adults in general may engage in. For example, Bishop (1988) described six very general mathematical activities that he considered people in virtually all cultures to be engaged in: counting, locating, measuring, designing, playing and explaining. National and international assessments nowadays take a similar approach: for example, the PIAAC Numeracy framework postulates four contexts that its items can refer to: work-related, personal, social and community; education and training (PIAAC Numeracy Expert Group, 2009). These approaches assume that claims can be made about numeracy practices that apply across and beyond any particular local contexts; they seek to explain numeracy at a global level.
Alternatively, the analysis can be done in a bottom-up ("grounded") way - by analysing the sets of practices that a particular group or community of adults may engage in. For example, Barton and Hamilton (2012) described the literacy practices of a community of adults in the northern English city of Lancaster. Street, Baker and Tomlin (2008) have studied numeracy practices, at home and at school, but mainly for school pupils. Marta Civil has explored the involvement of (bilingual) parents in mathematics education in the US state of Arizona (e.g. Civil, 2007). These approaches privilege the local meanings and practices of literacy and numeracy.

The tensions between the “generalising” versus “on-the-ground”, or the global versus the local, continue to be a source of frustration for ethnographic researchers who are concerned about the lack of traction in policy debates of their findings about the real, lived experiences of adults in their everyday contexts; on the other hand, policy makers struggle to see how policies can be based on research findings that are each so contingent on the particularities of the sites of the research. In their critique of a binary approach to literacy research, Brandt and Clinton (2002) argue the “limits of the local”, that is, “many human contexts are given to the activities of de-localizing meaning” (pp. 354-355): literacy “travels, integrates and endures” across different contexts (p. 337).

We can consider examples of different types of settings where adults might be expected to exercise their numeracy in contemporary industrial societies. For example, citizens are presented with statistics, often a plethora of statistics, during election (or referendum) campaigns in Western democracies. But what appear to be numerical riches are often less helpful than they seem. Political parties often fail to give the basic numerical (or other) information that any citizen would need, in order to be able to make informed decisions; e.g. the UK Conservative party’s refusal in the 2015 UK election campaign to specify where their £12 billion pounds of welfare cuts would be coming from over the next 3 to 5 years23.

Consumers are nowadays presented with much “choice”, e.g. in the decision about what energy tariff to take up with which company, whereas in earlier periods, they may have had little “choice”, especially if the sole provider was a nationalised industry. However, people have suspected many free-market firms of trying to obscure and confuse customers, by the complication or proliferation of pricing. In 2014 the UK Energy ombudsman responded by requiring energy firms to reduce the rich proliferation of tariffs (https://www.ofgem.gov.uk/sites/default/files/docs/2014/03/assessment_document_published_1.pdf). Since then, the UK Consumers’ Association has made a “super-complaint” to the Competition and Markets Authority (CMA), about supermarket retailers’ use of multi-buys and different pack sizes. “We’ve found retailers are confusing customers with tactics that exaggerate discounts and manipulate shoppers, so we’re using our legal powers to take the issue to the … CMA” (Which?, 2015).

Another case of trying to aid consumers in understanding what is being offered in the market has been the passing of legislation regulating the use of data, in advertising ‘pay day loans’. These examples suggest that numerical proliferation in itself does not necessarily provide clear information, nor facilitate confident “choice”.

In workplaces, the power relations in the workplace can hinder or extend workers’ mathematical knowledge. In Williams and Wake’s (2007) study in an industrial chemistry lab, the workers were

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2 Nevertheless, we do not suggest that data can ever be presented in a way that the theoretical or policy “implications” are straightforward: there is always room for debate / controversy. For example, one of the authors (Creese) led a workshop where adult teacher-trainees were challenged to come up with different conclusions about immigration in the UK, after being provided with the same official data on immigration.

3 We can nonetheless begin to think about the amount involved in this way: If over 3 years, that is “only” a cut of £200 pounds per citizen of the UK (population 60M +) on average … But, if concentrated on the poorest 10% of the population, it is £2000 over 3 years! See the suggestions for making big numbers meaningful in Blastland & Dilnot (2008, p129).
responsible for providing data to their manager, but were completely “black-boxed”, or excluded from information about the detailed workings of the calculation process, because the managers controlled the models that produced the calculations and the resulting decisions themselves.

Thus, the lack of numeracy apparently exhibited by adults is produced by a range of social institutions and practices, and thus any “blame” should really be shared across society, and not attached only to the adults themselves. We need to acknowledge the role of the powerful – individuals, political parties / governments, media and corporations – in determining the availability and the shape of the choices that are available, and of the information that is available, whether in textual or numerical (or digital) form. In particular, free-market businesses seem intent above all on “persuading” the individual to “consume”.

Therefore, when studying adults’ use of numerical (or other) information, we must take account of the “information providers (and gatekeepers)”, their powers and their methods. So far, rather than providing opportunities to use numeracy in a thoughtful way, or supports for this, these examples suggest barriers to the development of adults’ numeracy, in society at large. This suggests ways in which we might begin to think about the context of an adult’s numerate practices – what we might call their “numerate environment”.

The Literate Environment

In order to build up an understanding of what the numerate environment might entail, we now consider recent developments in the conception of the “literate environment”. In 2012 the European Commission convened a group of experts in the field of literacy (EU HLG) to carry out a review of literacy policy across Europe in response to what they termed Europe’s ‘literacy crisis’ – each year, hundreds of thousands of children start their secondary school two years behind in reading; some leave even further behind their peers. This has damaging consequences for their futures. And millions of adults across Europe lack the necessary literacy skills to function fully and independently in society.

In their final report the EU HLG suggested that adults’ skills respond to and are shaped by the literate environment in which they act. The notion of the literate environment is drawn from the world of development education, in particular the work of Peter Easton for UNESCO. Easton uses the term literate environment as “…a means of designating the contextual conditions and support required – both locally and externally – to make literacy fully sustainable.” (Easton 2014, p20).

The EU HLG concludes that adults’ skills respond to and are shaped by the “literate environment” in which they act and proposed the creation of ‘a more literate environment’ as one preconditions for success in tackling low levels of literacy among the European population. Their recommendations include:

- books and other reading materials should be easily available at home, in schools, libraries and beyond, on paper and online
- libraries should be set up in unconventional settings such as shopping centres or train stations
- parents “need help to improve their skills and confidence to engage their children in language development and reading for pleasure”
- reading promotion policies should stimulate reading and access to books, by organising media campaigns, book fairs, public reading events, competitions, and book awards”
- there is a “need to shift the mindset of all players in society – from parents to policy makers, from social and medical services to educational players, and from individuals
themselves to businesses – so that they see their engagement is crucial to promoting reading and writing (EU-HLG, 2012, p8).

The Report seems to offer mixed recommendations. On one hand, it wishes to encourage “adults to acknowledge their (sic) literacy problems”. Yet it also wants to encourage provision of “a variety of personalised learning opportunities” to “encourage providers of vocational education and training, and vocational teachers and trainers, to embed literacy instruction within their programmes [and to] recognise and validate non-formal and informal learning, putting a premium on adults’ achievements in experiential learning and tacit knowledge consolidation” (EU HLG, 2012, p12).

Nevertheless, the EU HLG argues that the responsibility for the literacy skills of adults (or the “lack” thereof) should be understood as shared across society, not as the individual responsibility of the adults themselves. And, in pointing to the availability of texts, the EU-HLG is emphasising the opportunities for exercising literacy skills in an adult’s everyday life.

The Numerate Environment

The High Level Group considered mainly literacy, in a broad sense. But, for our purposes, it is worth considering the concept of the numerate environment. Here we might notice that the “stuff” of the literate environment envisaged by the EU HLG was a range of different texts and opportunities and support to engage with them. What might be the analogue of these texts for the case of numeracy?

One possible answer is information, particularly quantitative information, numbers, represented in various forms, such as tables – but also including visual forms such as graphs and maps, and dynamic forms of these available from the use of modern IT: information in a numerate environment, like texts in a literate environment, is multimodal (Street & Baker, 2006). Numeracy practices involve the production of information, as well as its interpretation, use and critique.

If we note that information is becoming increasingly available, this could mean that opportunities to exercise numeracy are increasing. In this section, we give examples of opportunities (and supports) for numeracy mainly from the UK – but the work of these agencies is more widely accessible on-line, and we are confident that there are similar ones in many other countries. For example, the Open Data Institute (https://theodi.org) is an independent, non-profit organisation, based in London that aims to promote the availability and the use of many kinds of data, especially state statistics. The UK National Statistical Office (https://www.ons.gov.uk/) is the producer of a wide range of official statistics on the functioning of the UK economy and society, and has recently been working to make its website more user-friendly.

While we focus on information as one possible analogue to literacy’s “texts”, it is important to acknowledge that there are other possible analogues; one is “tools”, for example those of carpenters, whose use requires an embodied learning of the angle and distance to position various parts of the body, and the amount of body weight to put on the tool or the material it is working on to achieve the desired result.

But the story is somewhat mixed. For example, many people are excited by developments that are sometimes grouped under the title of “Big Data”; this includes previously unimagined streams of information, collected on peoples’ behaviours, choices, purchases and opinions, from surveillance cameras, loyalty cards, social media, etc. These data are often harvested by the state – but they are more and more gathered by private corporations – and both types of institutions often resell the data to other private bodies. This is the long-awaited information society! There are likely to be fierce struggles over the ownership of, access to, and control of data, e.g. medical records. Inquisitive citizens, who are concerned to understand better the workings of society, may have to struggle to maintain access to such data, even though they may have been among the original “producers” of it.
However, people will not necessarily find it easy to start using information, especially numerical information. Accordingly, we must investigate (and publicise) supports for ordinary citizens in exercising numeracy. We mention a number of these:

- Fact-checking agencies, which often offer free scrutiny of the statistics (and the logic) of claims about public policy or the achievements of political parties, e.g. Full Fact [https://fullfact.org/]
- Professional volunteers, which can be contacted in the UK, through the Royal Statistical Society (RSS) [http://www.rss.org.uk/RSS/Get_involved/Volunteering_opportunities_at_the_society/RSS/Get_involved/Volunteering_opportunities_at_the_society.aspx?hkey=ad2eab 87-9813-4274-bc8d-44f0751e827b] or the Radical Statistics Group (Evans & Simpson, 2016), RSS; or in the USA, through Statistics without Borders [http://community.amstat.org/statisticswithoutborders/home]
- Broadcasters: e.g. BBC Radio 4 “More or Less” [http://www.bbc.co.uk/programmes/b006qshd]
- Books, journals and websites produced by campaigning organisations such as Radical Statistics [http://www.radstats.org.uk/]; for example, Statistics in Society (Dorling & Simpson, 1999) and Visualising Information for Advocacy [http://visualisingadvocacy.org/].
- the wider culture: norms about presentation / discussion of numerical information (Blastland & Dilnot, 2008).

There is one agency that may not be replicated in many other countries: the UK Statistics Authority, which in certain cases can be asked to rule on a tendentious claim about the meaning of government statistics made by the media or by a politician, even the Prime Minister [https://www.statisticsauthority.gov.uk]

The opportunities and supports to exercise numeracy go hand in hand; without adequate and appropriate supports, individuals may not be aware that there are opportunities for numeracy development. Information on its own doesn’t present itself as an affordance in the same way to all people; “[w]hat becomes an affordance depends on what the organism does, what it wants, and what is useful for it” (van Lier, 2000, p. 252). Thus, besides the opportunities and supports for exercising literacy and numeracy skills at work, at home, and in the community, we should also ask: what are the demands for exercising such skills? If they are few, and if adults are not required to do calculations, or read graphs, or think about tables of data – as a consequence their skills may fail to develop, or even decline (Murray, 2009; Reder, 2009). This would leave a large sub-class excluded from the numerate environment, and relying on others for interpretation and access to information.

To sum up: We see three key aspects to a literate or numerate environment:

- the demands that the practices may make on the adult.
- the opportunities the practices may offer to the adult engaged in them
- the supports / resources offered, or conversely the barriers existing (or put up) within these practices, and cultures more generally, that impede the adult’s numerate development

We might group opportunities and supports under the heading of affordances; see for example, Greeno (1994). Supports means ways in which purposeful engagement with numeracy is made more achievable; that is, there is scaffolding that enables the learning adult to build from what they already know to achieve something they had previously not been able to achieve. So, while a literacy support might be through the use of language that is comprehensible and making features of the particular text type and how they help to achieve particular social purposes visible,
a numeracy support could also involve clarifying the social purpose of the information, how it is constructed and how the different elements are serving the purpose. Thus social interactions, either with an expert/teacher or with peers are important aspects of the meaning-making that is involved in numeracy development.

So if we, as educationalists consider numeracy courses to be the best support we can provide, it is a matter of concern that take up of these courses remains surprisingly low (if we accept the findings of surveys such as PIAAC). This may be because learners do not see these courses as relevant supports for them. A recent research project conducted by NRDC at UCL Institute of Education, into the impact of low levels of basic skills in the workplace, found very few employers or employees who saw a great need for staff to embark on a functional skills qualification, but there would have been interest in short courses on, for example estimation or interest rates (Carpentieri, Litster & Mallows, 2016).

Moreover, in considering learning needs for workers, Worthen (2008) identifies two different objectives in the workplace: one that is linked to increasing productivity, and one that is linked to the workers’ “earning a living”. In other words, the learning opportunities that may be readily offered by the employer are likely to be linked to numeracy (and other skills) that would increase the company’s profit margins. However, learning opportunities that help the workers to negotiate better conditions and pay are unlikely to be forthcoming from the employers, and in many contemporary de-unionised workplaces, unlikely altogether (Yasukawa, Brown & Black 2014). Similarly, those struggling to get by on low incomes may see little affordance from enrolling in a maths course – but may see the support offered by a short course on debt management. This obviously confirms standard theories of adult education, that adults engage with learning when they see a clear need for that education. The point here is that affordances need to be aligned to the individual’s numerate environment.

At the same time, we also need to highlight the opportunities for collective numeracy – i.e. numeracy as practices and skills created and held by groups, e.g. through trade union organising (Bond, 2000; Yasukawa & Brown, 2013; Kelly (2016). This is particularly important - but also challenging - in many workplace contexts where the ability for workers to organise has been eroded with the decline in the role of trade unions, substantially diminishing workers’ collective identity.

Within the home environment the most important actors in defining the numerate environment are parents. Their attitude to maths and numbers is crucial to setting norms to children. A household that values numeracy and how numeracy can enhance the family is likely to produce children and future adults who do not accept poor standards of numeracy (Civil, 2007). For this reason, Family Learning may be seen as having a potential impact, as it encourages children and parents together to build a better and more coherent numerate environment. However, such programs need to be sensitive to all of the dimensions that have constituted these family groups including the linguistic, cultural, historical, and economic (see for example Chodkiewicz, Johnston and Yasukawa, 2005).

**Conclusions**

The idea of a literate environment offers a way to think about the context of literate thinking and literate acts, and we think these ideas can be extended to numeracy. Describing the numerate environment for adults in the ways suggested above, leads to better understanding of adults’ uses of numeracy and how they can be supported. In this paper we have begun to construct a characterisation of the literate / numerate environment as including opportunities, supports (and barriers), and demands for workers and citizens to use their literacy and numeracy skills.

Our knowledge of the types of, or extent of, literacy and numeracy practices in which adults are encouraged/required to engage is currently inadequate for our purposes. Unless we fully
understand the demands on adults’ numeracy skills we will not be able to design learning programmes that support adults in meeting those demands as well as credibly demonstrating to employers, and others, that they can meet those demands. Such learning programmes may encourage more adults to improve their numeracy. What’s more, low demands on adults’ numeracy may have serious long-term consequences for individuals and societies. We know from Reder’s (2009) research, as well as PIAAC, that skills use and skills proficiency are linked:

adjusting for educational attainment and language status reveals that the positive relationship between practice and proficiency is strong. That is, adults who practice their literacy skills nearly every day tend to score higher, regardless of their level of education. This suggests that there might be practice effects (...) that influence proficiency (OECD 2013, p. 212).

It may be that the demands on many adults’ numeracy skills are low, or that they have developed strategies to largely avoid the use of numeracy, leading to a vicious circle of underuse and consequent loss of skills.

To help us to understand these issues we need to bring to bear qualitative research (e.g. Barton & Hamilton, 2012; Street, Baker & Tomlin, 2008) on literacy and numeracy practices that adults are encouraged / required to engage in – and on the consequences of low demand / mismatch between adults’ actual practices and those that are required for engagement in society.

At the same time, we need to develop our understanding of how learning and development unfolds in a numerate environment. To this end, our focus on affordances (Greeno, 1994), including opportunities and supports / barriers, and demands suggests that notions of learning as a goal-oriented activity, the zone of proximal development, and the role of mediating tools / people from Vygotsky’s (1987) individual learner-focused, and later Engestrom’s (2001) team-focused, versions of cultural-historical activity theory may offer productive tools to pursue studies, both of individuals and groups within numerate environments.

Finally, we must highlight the opportunities for collective numeracy – that is, numeracy as practices and skills created and held by groups, as discussed above. From a more general perspective, Blastland and Dilnot suggest that some of the changes required have to do with what one might call culture: “A culture that respected data, that put proper effort into collecting and interpreting statistical information with care and honesty, that valued statistics as a route to understanding, and took pains to find out what was said by the numbers we have already got, that regarded them as something more than a political plaything … would, in our view, be the most valuable improvement to the conduct of government and setting of policy Britain could achieve.” (2008).

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Nursing Students’ Readiness for the Numeracy Needs of Their Program: Students’ Perspective

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Abstract
Numeracy needs of nursing students are often underestimated by students when they enter university. Even when students are aware of the mathematics required, students underestimate or overestimate the skills they
have. Research has highlighted the mathematics and numeracy skills required of nurses and nursing students and numerous studies have tested these skills. Research highlighted in this paper investigates students’ perceptions of these skills generally, and students’ retrospective reflection after having finished a course. Results indicate both an underestimation and overestimation of students’ skills when compared to students’ results.

Key words: nursing, skills, numeracy

Introduction

In nursing, the numeracy skills required are considerable. Research with nurses (Blais and Bath 1992; Hoyles et al. 2001) and nursing students (Hutton 1997; Gillies 2003; Galligan 2011) has highlighted the links between nursing skills, particularly drug calculation skills, and underlying mathematics skills. These skills include: number; ratio and proportion; scale; decimals and fractions; rates; measurement; algebra; graphing; and problem-solving. Many researchers have highlighted the proportion of nursing students who have poor skills in these areas (Hoyles et al. 2001). Others have highlighted university students’ difficulties with reading graphs (Kemp and Kissane 2010); understanding algebra (Pierce and Stacey 2001) or reading skills, particularly with word problems (Newman 1983). These conceptual barriers are exacerbated at some universities where there is a high proportion of mature-aged students who have been away from formal study for a number of years. While there has been studies investigating nursing students’ confidence in mathematics (e.g. Glaister 2007), to date we have not found any research that has investigated students’ opinions of their skills after their study.

A four year project, based at a regional university in Australia, aimed to investigate students’ perceptions of their mathematical readiness. At this university, the percentage of mature aged students is considerably higher than the sector (58% to 24%) and the percentage of those aged 30 and over is about 45% compared to the sector at about 15%. The number of students identified as low Socio-Economic Status (SES) is 34%, double that of the sector at 17%. The project investigated students’ perceptions of their readiness for the quantitative skills needed in their courses after having completed the course. It also correlated this with a mathematics assessment of student readiness, completed within one course. In our preliminary results (Abdulla et al. 2013), we found up to 30% of students in business, education and nursing felt poorly prepared for some of the quantitative components in their courses. However, this was a small preliminary study and did not look at individual courses within a program. Our subsequent surveys in 2014 and 2015 revisited most of the questions asked in 2012. This paper outlines student readiness from the perspective of nursing students and draws on survey data of 160 students in 2015.

Method

For this paper we draw on data from nursing students enrolled in Semesters 1 and 2 in 2015. Three types of data were used: student surveys on perceptions of their readiness; student results from quizzes in a course; and the student comments at the beginning of semester on their level of skills in selected questions.

Ethics clearance was obtained to survey and communicate with students and staff.

The survey was trialled in 2012 and 2014. Students were encouraged to participate by offering them the chance of winning a $100 book voucher. The survey link was emailed to the students after the semester results had been released and about half of the students also agreed to be interviewed. The average response rate in 2015 was about 10%, noting that we also invited students who dropped the course (see Table 1).
The questions that the students were asked included basic demographics. Perceptions of their preparation in various topics were sought using a Likert scale. The topics included: calculator use; decimals; percentages; ratio; algebra; statistics; and problem solving. Students were also asked if their overall mathematical preparation was adequate for the course in question. There were a number of open-ended questions to further explore what factors students understood contributed to their success or failure. While most students answered at least one question on the survey, the response rate for most of the open-ended questions was lower.

Qualitative data from the relevant questions were downloaded into Word and then transferred to NVivo where it was analysed using constant/comparative method (Wellington 2015). Some attempt was made to capture the conceptual as well as the thematic regularities in the data but most of the answers were too terse to be really useful in this regard.

**Key Findings**

**Survey**

Over 60% of respondents were over 25 years old. While 35% of respondents had studied some mathematics in the last two years (see Figure 1a), a substantial percentage (over 30%) of students who responded to the survey had been away from study for more than 10 years, with many only having completed mathematics to year 9 or 10 (see Figure 1b).

“Enabling” mathematics is pre-university studies at a college of the university, designed so that students can meet the entry requirements of university degrees. “Basic” and “Advanced” Maths refer to levels of senior high school mathematics; “Advanced Maths” contains calculus.

Figure 2 shows how adequately students felt their pre-university mathematics had prepared them for mathematical concepts encountered in their university studies. Students felt most prepared for using calculators and graphs and least prepared for ratios, fractions and algebra. While students

<table>
<thead>
<tr>
<th>Semester (completed final quiz)</th>
<th>No. responses</th>
<th>No. invited</th>
<th>No. cohort dropped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1 (402)</td>
<td>48</td>
<td>647</td>
<td>154</td>
</tr>
<tr>
<td>Semester 2 (203)</td>
<td>29</td>
<td>386</td>
<td>87</td>
</tr>
</tbody>
</table>

Figure 1a. Years between pre-university mathematics and starting Nursing degree ($n = 85$).

Figure 1b. Proportion of students' pre-university mathematics preparation ($n = 84$).
said they felt less prepared for statistics, there was little statistics in the course (but there was some
statistics in other nursing courses).

Comparison of perceptions with results

The following section compares students’ perceptions with results on four quizzes they completed
during the semester and a final quiz. All the quiz questions posed had also been discussed in class
(or via online lectures) or were in the study materials. Students were asked to do the online quiz
within a time limit, and some of the questions were tested multiple times. Previously, Galligan
(2011) had found that, in similar quizzes, up to 1/3 of errors could be due to misreading the
question. This was also found in many of the questions asked. For example a question:

Example 1: Write the following in numerals: Eighty Thousand Two Hundred and Six. For example,
twenty one = 21. (Note: please do not include spaces or commas in your answer)

In Example 1, 70% of the 77 students surveyed were correct in the final quiz. The most common
incorrect answer was 8206 and one person each had 800206; 82006; 80,206; 80260 or similar.

Decimals

Approximately 80% of students surveyed felt prepared for decimals (Figure 3). In the final quiz,
when specifically asked questions about: converting from a fraction to a decimal (91% correct);
to round to so many decimal places (92%), students were generally competent. However, when
asked to read a syringe with gradations, as in Example 2a, only 77% of students were correct by
the end of semester.

Figure 3. Example 2a
On a similar question in three earlier quizzes, 32%; 42%; and 37% of students were incorrect. Of those who were incorrect, at least half was due to reading the gradation incorrectly (i.e. reading the above as 8), as opposed to reading it at the incorrect point (i.e. saying 0.75 or 0.85 instead of 0.8). Similarly, students were asked to read various graphs in a health context. For example when asked to read a temperature (as seen in Example 2b) that needed decimal interpretation, 6% of students were incorrect by the end of semester with many of these students answering 37 or 37.5 instead of an answer above 36.5 and below 37.

Fractions

Figure 4 shows 75% of students felt prepared for fractions. Most students (84%) could convert a fraction into a decimal form (where the fraction was $\frac{1}{a}$ with $a < 10$, Example 3a), and 89% were able to simplify $\frac{20}{120}$ to $\frac{1}{6}$ (Example 3b), but when asked to find a fraction of a number, as in Example 3c, the proportion dropped to 52%.

<table>
<thead>
<tr>
<th>Questions involving fractions</th>
<th>% correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. What is $\frac{1}{7}$ as a decimal? (Quiz 2)</td>
<td>84</td>
</tr>
<tr>
<td>b. Express $\frac{20}{120}$ as a fraction in its simplest form (Final Quiz)</td>
<td>89</td>
</tr>
<tr>
<td>c. Find $\frac{2}{5}$ of 4 mL, if $a$ is 85 mg and $b$ is 190 mg. Answer to the nearest one decimal place. (Quiz 3)</td>
<td>52</td>
</tr>
</tbody>
</table>
Percentages

Over 80% of students believed they had adequate skills in percentages (Figure 5), and in the final quiz 90% of students could calculate 30% of 80. However, when tested with contextual problems, the percentage that were seen to be proficient was as low as 46%. For example, in Quiz 3 for a large proportion of students, the mistake was in reading the problem (Example 4). In Example 4a, many of those that did not get the question correct was due to their ignoring the word “remains”. In addition, in Examples 4b, c, and d, many students were not rounding correctly. In another question (Quiz 1) asking students to round 23.123 to the nearest tenth, 34% of students were incorrect.

<table>
<thead>
<tr>
<th>Quiz 3 questions on percentages</th>
<th>% correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A bag of saline solution contains 250 mL. From this bag 139 mL has been drained. What percentage remains in the bag?</td>
<td>46 (increased to 64% in final quiz)</td>
</tr>
<tr>
<td>b. A person increased weight from 52 to 65. Express this increase in weight as a percentage of the original weight. Answer to the nearest whole number.</td>
<td>59</td>
</tr>
<tr>
<td>c. A person has burns to 9% of her body. If her surface area is about 1.6 square metres, what area of her body has been burnt? Round your answer to two decimal places.</td>
<td>67</td>
</tr>
<tr>
<td>d. In a certain country of 25 million people, the number of deaths from heart disease in 2008 was 1809. Express the number of deaths as a rate per 100 000. Answer to the nearest whole number.</td>
<td>62</td>
</tr>
</tbody>
</table>

![Figure 9. Students’ perception of preparedness for percentages.](image)

Ratios

While 75% of students believed they had adequate skills in ratios (Figure 6), when tested the percentage that were seen to be proficient with these particular skills was as low as 54% (Example 5).
While 86% of students believed they had adequate skills in graphing (Figure 7), when tested the percentage that were seen to be proficient with these particular skills was as low as 57% (Example 6).

In Example 6, 43% of students were incorrect with most students answering 33%. This was due to not taking into account those aged 25–44, i.e. not subtracting the 5%.

**Problem solving**

While 79% of students believe they had adequate skills in problem solving (Figure 8), when tested the percentage that were seen to be proficient with these particular skills was as low as 34% (Example 7).
In Example 7, students were given the label and asked to identify the “amount in each unit” and the “volume” as would be needed in the standard formula. In the quiz 56% and 34% of students were correct respectively.

### Algebra

A greater proportion of Students tended to be under-confident with Algebra, with only 67% stating they were prepared (Figure 9).

<table>
<thead>
<tr>
<th>Quiz questions</th>
<th>% correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. To calculate the volume of an injection a formula is $\frac{SR}{SS} \times V$. Find the volume if $SR = 322; SS = 30; V = 4$</td>
<td>96</td>
</tr>
<tr>
<td>b. If $B = \frac{w}{h^2}$, what is B if $w = 116$ and $h = 2$ (Round your answer to 1 decimal place)</td>
<td>91</td>
</tr>
<tr>
<td>c. If $V = IR$ then $I = ?$</td>
<td>57</td>
</tr>
</tbody>
</table>

In Example 8, while 96% and 91% of students were correct for Example 8a and b, this dropped to 57% correct for Example 8c.
Overall

Figure 10 compares students overall mark on a final quiz, which incorporated a variation of all the questions above, and their perception of preparation. In the nursing context, we consider a mark of 85% as well prepared. If students’ marks were over 85% then they should perceive themselves more prepared than if they received less than 85%. Note there are 11 (about 20% of the students with over 85%) students who are under-confident, i.e. with relatively good marks but with a perception that they may have not been prepared enough. There are also 15 students (65% of the students with less than 85% correct) who are over-confident, i.e. with relatively poor marks (in the context of nursing numeracy) but with a perception that they were prepared enough.

![Bar chart](image)

*Figure 18. Overall mark on final quiz and perception of preparation.*

**Discussion**

When answering the question “Was your overall mathematical preparation adequate for the course [ABC]” we realise students may take different perspectives. Some students may think that even if they were incorrect in some questions, their mathematics preparation was adequate since they passed the course. Others may think that even if they were correct in most of the questions, and received over 85% in the course, there were feelings of uncertainty around some concepts. We wanted to explore this a bit further. Figure 11 summarizes the comparison between students’ perception of their readiness and the results of one question in each of the topics (examples 2a; 3b; 4a; 5b; 6; 7; and 8b). The choice of the question was subjective, but we felt if we averaged the results, we would lose the essence of the concepts. For some of the topics there was overlapping concepts, so the problem with a question such as rearranging a formula \( V = IR \) could be related to algebra or ratio and the fact it may be related to both, could compound the problem and cause an increase in error rate. Another issue is students’ careless reading of many tasks and their misunderstanding of “rounding”, so at times the error rate reflects both difficulties in a concept, as well as other factors. Of the seven topics, two of them show some mismatch – graphing and algebra. It appears that students are over-confident in graphing and under-confident in algebra.
Summary of the difference between students’ perceptions and their results in one question in their quiz.

Table 2 highlights these differences (shaded area) with 38% of students saying they were prepared but were incorrect in the graphing question (Example 6) and 30% of students saying they were not prepared but were correct in the algebra question (Example 8b).

Table 2
Two-way table of students’ perceptions and their results in selected questions in graphing and algebra

<table>
<thead>
<tr>
<th>Graphing</th>
<th>Prepared</th>
<th>not prepared</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>33 (45%)</td>
<td>8 (11%)</td>
<td>41 (55%)</td>
</tr>
<tr>
<td>Incorrect</td>
<td>28 (38%)</td>
<td>5 (7%)</td>
<td>33 (45%)</td>
</tr>
<tr>
<td>Total</td>
<td>61 (82%)</td>
<td>13 (18%)</td>
<td>74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Algebra</th>
<th>Prepared</th>
<th>not prepared</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>45 (61%)</td>
<td>22 (30%)</td>
<td>67 (91%)</td>
</tr>
<tr>
<td>Incorrect</td>
<td>6 (8%)</td>
<td>1 (1%)</td>
<td>7 (9%)</td>
</tr>
<tr>
<td>Total</td>
<td>51 (69%)</td>
<td>23 (31%)</td>
<td>74</td>
</tr>
</tbody>
</table>

Conclusion

This paper is part of a larger study on university students’ perception of their readiness for the quantitative skills of courses they have completed (Abdulla et al. 2013) and is a follow up study to previous research on lecturers’ perceptions of their students’ readiness (Galligan et al. 2013). In this current section of the study, we investigated first year nursing students’ perception of their readiness for one course in nursing numeracy and compared this perception to student results.

We found up to 35% of students surveyed felt less than prepared for some elements of their course. When comparing surveyed students’ perceptions with final quiz results, up to 65% of students were overconfident on their level of preparedness. While students appeared competent in many of the basic areas of mathematics, when questions became more complex, the competence level...
decreased. In the context of teaching nursing students numeracy, it is important to highlight to students the complexity of many of the basic numeracy skills encountered in their nursing degree and careers. In particular, students appear to be overconfident in their interpretation of graphs, and are unaware of other numeracy skills required to correctly interpret graphs (Kemp and Kissane 2010). On the other hand, students often find algebra a sticking point in their mathematics learning and are often unaware of the skills they already possess. Students may not be able to perform many of the tasks set by them in high school (such as rearranging equations or factorising expressions) but they are able to understand and use formulas in the context of nursing.

As the survey response rate was relatively low, care needs to be taken with generalisation of any results. However, the under and over-confidence rates do generally match previous results in similar research (Galligan 2011). While this study is in one university in Australia, the issue of student perception of preparedness is applicable in any higher education context where quantitative skills are assumed. In particular, it is relevant to such institutions where there is a high proportion of mature aged students and students who are unfamiliar with the expectations of university. There is a need to provide students with clear guidelines as to the standard of mathematics expected of them at the onset of their study. Good support and enabling programs also need to be in place to assist underprepared students to realise these expectations, so they can be retained as successful students and progress to become quantitatively competent and confident in their career.

**References**


Mathematics Dialogic Gatherings: A Way to Create New Possibilities to Learn Mathematics

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Abstract

This paper introduces the Mathematics Dialogic Gatherings (MDG) as a successful way to encourage adults’ learning of mathematics. We report on a group of adults who attended a MDG in an adult school placed in Barcelona. Participants in this group do not have an academic trajectory. They attend once a week a session in the adult school, where they read, share and discuss paragraphs from textbooks of mathematics. Popular gatherings are a historical way for adults to learn in Spain. MDG are based on the dialogic learning approach developed by Flecha and others. In this session I will provide evidence on adults’ discussions illustrating how they scaffold themselves through egalitarian dialogue to learn and understand the mathematical concepts included in the textbooks used within the MDG. Drawing on the data collected, I argue that adults learn as a result of a dialogue in which they negotiate the meaning of the mathematical objects discussed, using dialogic talk. I conclude that MDG have the potential to create further learning opportunities especially for those who have never attended formal school courses, or dropped out of their school.

Key words: Mathematics Dialogic Gatherings, classic readings in mathematics, dialogic learning

Mathematics Dialogic Gatherings (MDGs) were first implemented during the 1980s in La Verneda Adult School, in Barcelona. This school is well-known internationally because being the place were Dialogic Literary Gatherings (DLGs) started in late 1970s (Soler, 2015). At that time, Ramon Flecha, with other friends, lead a community-based movement demanding for a public adult school in a working-class neighborhood, in Barcelona. A group of people, most of them without academic experience (they never attended any school), occupied a famous building in that neighborhood turning it into a community center. They began to learn in that building, and they created the adult school. Some of them formed a group who decided to read classic texts. People, who barely had attended a school, started reading Ulysses by Joyce, Don Quijote de la Mancha by Cervantes, or Hamlet by Shakespeare, using dialogic learning (Flecha, 1997). In 1999 this school became the first Spanish educational experience published in the Harvard Educational Review (Sanchez, 1999). Now thousands of people have conducted DLG all around the World (Flecha, 2011; De Botton et al., 2014; Serrano & Mirceva, 2010).

Following the path opened by these people, a group of six women begun to met every week in an adult school, in Barcelona, reading the classics, but in the field of mathematics. This paper is the story of those women, the first MDG. First, I will provide the theoretical framework to understand the basis of MDGs. Then, I will describe the ways in which MDGs work. Going back to the founders of DLGs, I will offer a justification as to why is it important to use classic readings rather than any other type of reading. Finally, I will discuss adult mathematics learning drawing on a particular example coming out from the MDG meetings.
Theoretical Framework

Mathematics literacy involves a number of abstract cognitive skills, or what Vygotsky would call “high mental functions.” During the last century, Piaget’s ideas were celebrated and quoted to claim that cognition is a developmental process in which individuals construct knowing. He proposed the idea of cognitive “schemas” to understand what happens when someone learns a concept. In his Genetic Epistemology Piaget conceived the schemes as units of analysis to represent “units of learning.” In this sense, for instance, there is the scheme of number, defined as a mathematical concept involving quantity and order position within a series. The next number is always bigger than the previous one (1, 1+1,…, n+1, being n+1>n). This is the “rule.” Then, Piaget claimed that learning happens when the individual needs to solve a cognitive conflict between his/her scheme and new information coming from the “environment.” In our example that conflict could arise when someone tell us that in between two numbers there is always a “new” one. Then, the “solution” for our “conflict” is rational numbers. We always look for equilibrium. When new information appears (threatening our original cognitive “equilibrium”), we tend to accommodate the new information into our scheme to get a new “equilibrium.” This effort of accommodating is what Piaget calls “learning.” According to him, children go through a series of stages, from simple reflexes (sensorimotor stage) towards abstract thought (formal operational stage). Learning is “determined” by age. The cognitive development is a linear process in which individuals move from concrete operations to formal (abstract) ones. In the realm of adult education Erikson went further proposing the stages of psychosocial development (Erikson, 1959). Later studies have fully rejected Piaget’s assumption that learning depends on age (Mehler & Bever, 1967).

The core idea of Genetic Epistemology about schemes and the process of “assimilation-accommodation-equilibrium” has been accepted by the international scientific community. But learning is not just an individual process; it is a social one. According to Vygotsky (and his followers), learning emerges as a result of social interactions within individuals with different ability levels. When there are two or more people, it is always possible to create what Vygotsky (1978) called “zone of proximal development;” every individual within the group can achieve his/her “potential” mathematics ability with the help of someone else that already can do it. Later on, David Wood, Jerome S. Bruner and Gail Ross (1976) developed the idea of “scaffolding” in trying to understand how this process works (as a learning process). According to them, the teacher supports the students’ thinking giving them “hints” thus students can build their understanding over them.

This approach has been also used with success within the adult learning mathematics field. Catherine A. Hansman (2001) claims that adult learning occurs in context between adult learners’ interactions among them. Talking about parent involvement, González, Andrade, Civil and Moll (2001) also used this approach to characterize how adults use their previous knowledge to create “zones of practices in mathematics,” resulting learning as a consequence. However, although all these studies seem to confirm that learning is a social process in which people participation in heterogeneous groups (or pairs) participate in mutual interactions to support each other, they do not explain how does it work this social process.

Neil Mercer (1995), who has dedicated his professional life to investigate the role of language and the development of children’s thinking, published a taxonomy to differentiate between “disputational, cumulative, and exploratory talk.” These three categories help us to understand how individuals (students, adult learners, etc.) use language to learn. Mercer explores the relationships between quality of dialogue, reasoning, and academic results. In doing so, he ends up with the idea of “exploratory talk,” which is this kind of talk that individuals use to share relevant information, engaging with others’ ideas. According to Mercer,
Exploratory talk, by incorporating both conflict and the open sharing of ideas, represents the more ‘visible’ pursuit of rational consensus through conversation. More than the other two types, it is like the kind of talk which has been found to be most effective for solving problems through collaborative activity.

(MERCER, 1995, p. 105)

Drawing on this idea, it seems that “learning” is somehow connected to dialogue and reasoning. In recent years, Díez-Palomar and his colleagues (Díez-Palomar & Cabré, 2015; Garcia-Carrión & Díez-Palomar, 2015) proposed the idea of dialogic talk as a methodological instrument to analyze in fine grain the interactional events when two or more individuals work together to solve a mathematical task. Taking dialogue as a medium to observe cognitive learning, Díez-Palomar and others explore how learners justify their statements when working with peers and/or the teacher. Learners may use dialogic talk (defined as a type of talk in which participants use valid claims to justify their answers, that can be verified by everyone who is involved in the interactive event), or non-dialogic talk (which is the kind of talk grounded on power claims emitted by someone who is using his/her position of “power” to justify his/her statements). Evidence suggest that learning is more likely to appear when within an interactional event dialogic talk is predominant, rather than non-dialogic one.

MDGs are spaces where participants should use dialogic talk when sharing their thoughts regarding a mathematical idea coming out from one reading in mathematics. Next, I will define MDGs and how they work.

Mathematics Dialogic Gatherings

The Dialogic Literary Gatherings (DLGs) created by Flecha and a group of [mostly] women, without any academic degree, in 1978, in Barcelona, inspires MDGs. DLGs are one of the successful educational actions (SEAs) identified in the research project INCLUD-ED. Strategies for inclusion and social cohesion from education in Europe (2006-2011). This research project has transformed the social and political impact of educational research all over Europe, since most of its findings provoked the creation of new educational propositions approved by the European Parliament, European Council and parliaments from diverse member states in Europe (Flecha, 2014). DLG is a dialogic reading activity where participants read the classics (like Shakespeare, Cervantes, Kafka, Wilde, Woolf, Alighieri, Austen, Homer, Hugo, Goethe, Lorca, etc.).

![Figure 1. Scheme of how a MDG works.](image-url)
Then, they met once a week to share their reading (questions, curiosities, further information, personal narratives, etc.) sharing words, meanings and reflections. They use the dialogic methodology which state that every person must invoke validity claims to justify his/her words within the dialogue.

Figure 1 displays how DLGs work. In doing so, the participants within the DLGs are exposed to elaborated codes (in Bernstein’ terms), but they also have the time and the support to connect such words to non-formal ways to say the same idea. In this sense, DLGs become spaces for people to share their previous knowledge, and learn new ideas making meaningful bridges between their notions. Participants become literate in using high quality texts. This is the reason of using classic readings: because this type of book contains an established quality text including appropriate vocabulary and grammar. Using these readings, adult learners have more chances to improve their literacy skills.

In a similar vein, in the MDGs we use classic readings in mathematics (and sometimes sciences as well). We read Euclid, Archimedes, Copernicus, Galileo, Kepler, along with Boyer, Klein, Jean-Paul Collette, etc. Participants choose a classic reading in a topic, for instance: history of the number systems. Then, they agree on the number of pages to read at home. Next week everyone meets again, to share his/her reading. The facilitator asks the participants who wants to share his/her “paragraph,” because everyone highlights sentences or paragraphs at home, for sharing. Then, the discussion begins. The facilitator selects the order of those speaking. If someone who never participates raises his/her hand to share something, this person has the priority rather than those participants who always talk. Egalitarian dialogue is the rule. Everyone can share a sentence (a question, a comment, etc.), and everyone’s opinions are respected. All participants should draw their comments on validity claims (susceptible to be verified by the rest of the group). In this way, if someone makes an error, another participant can ask for clarification until the justification or the argument is mathematically correct. MDGs are perfect examples of what Bakhtin (2010) called dialogism and polyphony. According to him, speech acts include others’ voices, styles, references and assumptions (polyphony); hence dialog is a complex cultural situation in which participants share their own voices (previous knowledge, personal experiences and narratives, assumptions, etc.). Using this theoretical approach, we can assume that learning is the sum of all these voices, but in a context of egalitarian dialogue (Flecha, 2000) where everyone uses dialogic talk.

**Methodology**

In this article I’m discussing a case study using qualitative methods based on an ethnographical approach, using communicative methodology (Aubert, 2015; Gómez & Munté, 2016) as a framework. Ethnography attempts to understand social and cultural situations including the perspective of the participants involved in the study. It involves a close relation between the researcher and the participants. The researcher becomes a member of the community observed. I collected the data during the school year 2015-2016. The setting for the study was an adult school placed in a working class neighborhood in Barcelona. I arrived at this school seventeen years ago, in 1999. I served as a volunteer to help adult learners to develop their skills in mathematics. Along the way, I worked with individuals who never attended a school before, individuals with few notions about “school-mathematics”, and individuals who had a strong mathematical background in formal mathematics. Eventually I became member of the community. I taught them and I learnt from them. I was able to understand many different ways to do and talk about mathematics. Being part of the community, I was invited to create a MDG using classic readings in mathematics, to learn from the classics with people that have not any academic degree. I asked them to allow the presentation of their dialogues in the annual conference of ALM. They agreed, so I did it.

I collected data every week. Participants include six women between 40-years-old and over seventy-years-old. I audiotaped all the sessions during the last semester in 2015-16 (from May to July 2016). I also took field notes in my diary, from the classroom observation. This set of data
was transcribed partially. The communicative methodology underpinned the data collection, analysis and interpretation. I worked assuming a position of “egalitarian dialogue” with all the participants in the MDG. In the next section I try to build on their voices.

Table 1.

Analysis of the speech acts. Types of talk

<table>
<thead>
<tr>
<th>Interaction Type 1</th>
<th>Interaction Type 2</th>
<th>Interaction Type 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange of information</td>
<td>Non-dialogic interaction</td>
<td>Dialogic interaction</td>
</tr>
<tr>
<td>No argumentation</td>
<td>Arguments are based on power claims</td>
<td>Arguments are based on validity claims</td>
</tr>
<tr>
<td>Example: memorization</td>
<td>Example: authoritarian order</td>
<td>Example: egalitarian dialogue</td>
</tr>
</tbody>
</table>


In terms of data analysis, I used discourse analysis focusing on the relationship between language and cognition—in mathematics. Discourse analysis grew up during the 1960s and 1970s. At that time linguistics were more interested in understanding single sentences. But in 1952 Harris published an article titled ‘Discourse analysis’ looking on the links between text and its social context. Later on, other scholars provided seminal works on the study of speech in its social setting (Hymes, 1964 or Searle, 1969). Linguistics and socio-linguistics were concerned not only with the grammatical and lexical forms of what is said, but, more importantly, on what people can do with words (Austin, 1962). People with words can actually create “opportunities for learning” for other people. They can create ZPD where other peers can receive support and develop their cognitive potential. For this reason, I used the codes presented in table 1 to analyze dialogue during the interactions occurred during the meetings. I used utterances (from the dialogues) as unit of analysis. Within these utterances, I looked for interactions of type 1, 2 or 3.

Interactions type 1 are defined as interactions in which individuals use language to share information. They do not explain, nor justify, their statements. They just exchange information. The type of learning associated with interactions type 1 is memorization, because it is low demanding in terms of cognition. The interaction type 1 does not require any “understanding” of the idea transmitted.

Interactions type 2 are defined as non-dialogic interactions. Participants use language to express mandate, order. Justification of the correctness, veracity, and truth of the statement is based on the power position that occupies the person who pronounces the sentence. This is the case of a statement like “2 plus 2 equals four, because I am the teacher and my authority is based on my position of power in front to the students.”

Interactions type 3 are defined as dialogic ones because participants always use validity claims to justify their arguments. Correctness, veracity or truth are based on valid claims emitted by the speaking person. The audience can verify those valid claims. For example, “2 plus 2 is four, because I’m placing 2 pieces of paper on the table, then I’m adding 2 more pieces of paper, and then I’m counting with you all the pieces, being four the last number that I pronounce when finishing all the pieces of paper over the table.” Interactions type 3 may create opportunities for participants to build on those valid claims to understand the mathematical concepts discussed within the dialogue.
Results

In this paper I discuss the interactions occurred during a session about The Number System. We were reading “Historia de las Matemáticas” the Spanish translation of Jean-Paul Collette (1979) book “Histoire des Mathématiques.” At the beginning of the first volume, Jean-Paul Collette introduces the origins of the mathematics (Prehistory, Babylonians, Greeks, Romans, etc.). He talks about the different forms to represent numbers, as well as different number systems. Along the pages, we (the participants in the MDG) held a discussion about the first marks in a bone found in Ishango that archeologist believe are tally marks. I shared with the women that the marks seem to be grouped keeping records of 28 days, which scientist belief that correspond to lunar cycles.

The conversation came along, and a genuine interest about where the numbers come from appeared. Someone noticed that there are different types of numbers: Sumerian, Egyptian, Greek, Roman, Hindu-Arabic, etc. Ancient people used different ways to represent numbers, but using tokens (in Sumeria) was a huge advance since it allowed people to perform easily the first arithmetic calculations, adding or removing some tokens from the full set. I noted that using tokens was also important because you can use an object (a token) to represent an abstract idea, in this case, the number. In this sense, numbers are “connected” to their physical representations in a bi-univocal relationship. We discussed what does the word “bi-univocal” mean, using different numbers as examples to illustrate it. We used pencils to represent numbers, and then I wrote down on the whiteboard a series of marks and their link to its numeral, from one to five. We noteded that ancient people discovered that relation (Aida claimed that “ancient people were smarter than us, because we use numbers, but they discovered numbers.”) In so doing, concepts like numeral, quantity, cardinality, ðβεα (in Plato’s sense) emerged in our dialogues.

Then, one of the participants, Carlota, raised another topic for discussion: she shared a paragraph from the book talking about how decimal numbers travelled from one civilization to another (see lines 5 and next in the transcript).

[1] Carlota: The number system…
[3] Carlota: Page 12… almost at the end of page 12...
[5] Carlota: it says... “The decimal system is well know and used by the Arabs, who passed
[6] us in the Iberian Peninsula during the period of Al-Andalus and then it was disseminated
[7] through the whole Europe. In turn, the Arabs took it from the Hindus, as we can see in
[8] the figure.” This caught my attention because I did not think that it was that old...
[9] Volunteer: Aha. And what the rest of you think? It came to your attention the same
[10] issue?
[11] Cèlia: yes, yes... I do. It’s like in the Roman times, when... When... Explaining the
[12] numbers... Or when on TV they start to cross out the numbers on a piece of wood
[13] [referring the notches on the Ishango bone]
[14] Carlota: The Arabs seems to have three more numerals than Roman people... Can it
[15] be?
[16] Volunteer: I don’t know, I had not ever thought... Let’s see, could you further explain...
[17] Carlota: Romans seems to have, one, five, ten, fifty, hundredth and thousand. And they
Carlota makes an interesting point in line 11. She wonders if Arabs had more numerals than Romans. That attracted my attention since I thought that this question was a very important one. Carlota, in fact, was noticing that there are more numerals in the Hindu-Arabic number system, than in the Roman one (see Table 2).

We counted that whereas in the Hindu-Arabic number system we have 9 different numerals (at this point there was no mention of zero), whereas in the Roman one we only have 7 numerals. The next question was “how can they count with only 7 numerals?” Someone said that ancient Romans were “troublemakers” with such a numerical system. “Our numbers are easier” Célia said. “Why?” I asked. Alba said that “our” numbers are easier because we are used to them.

Table 2

<table>
<thead>
<tr>
<th>Hindu-Arabic</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roman</td>
<td>I</td>
<td>V</td>
<td>X</td>
<td>L</td>
<td>C</td>
<td>D</td>
<td>M</td>
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</table>

During the discussion, we discovered that in order to represent quantities like 2, with Roman numbers, we should use the symbol I two times (II); but to represent quantities like 4, then we have to do some calculations using the Roman numerals (5-1=4; hence four in Roman numerals is IV). We discovered that the rules to represent the numbers with the Roman numerals were somehow complex (never use the same numeral four times in a row; repeating a numeral up to three times means addition; a small numeral to the left of a larger numeral means subtract the larger minus the smaller, but on the opposite means addition).

Then Carlota contributed again by mentioning “zero.” She realized that zero was not among the numerals that they were discussing. She repeated that there are more numerals among Hindu-Arabic system than in the Roman one. She was estimating that “our” numerals are three times more than the Roman ones…I which was a bit high as estimation. Then, I asked Carlota “what are those numbers?” (line 26) She guessed that zero may be one of them. Then, Alba jumped into the discussion and said that 3 and 7 should be also part of “those numbers [numerals].” She mentioned another interesting idea “10-based system.” (line 29) This notion added a new layer to our concept of “number system.” It seems that number systems, in addition to numerals, quantities, cardinality, and so on, also have something called “base.”

[18] Fe: From one to nine.

[19] Carlota: Zero, I do not know…

[20] Fe: This is ten, isn’t?

[21] Alba: What are the numbers you mentioned?

[22] Carlota: Look, the one… those are the Roman [numbers]: the one, the five, the ten, the “L” means fifty, “C” is a hundredth, “D” is five hundredth, and “M” a thousand.

[23] Many at the same time: Yes!

[24] Carlota: But the Arab [numbers] it seems that they have three more numbers.
Volunteer: So, what are those numbers?

Carlota: One must be the zero... I do not know...

Alba: And the three as well. Of course. And the seven. It says so here. Three, seven and zero. Zero, three and seven. Well... I see that... They used a 10-based system... I mean... Everything is 10-based... Ten, twenty, thirty... They move from ten to ten...

Or from twenty to twenty... Or from a hundredth to hundredth... But the base is ten...

That's what they decided...

Volunteer: Aha... They?

Aida: They means the Arab people. Yes, zero, six and nine... It says that it was upon a time... It was upon a time, in Florence, that people did not like those numbers [Arab numbers] because it was so easy to falsify them. It says: "At the end of the XIII Century the Florence Government passed norms against the use of those symbols because it was very easy to falsify the zero, the six and the nine." That is, they did not want the Arab numbers because that because it was very easy to falsify.

Alba provided a clear example of what 10-based system means. In lines 28 to 32 she mentions that in a 10-based number system “everything is 10-based... ten, twenty, thirty...” She was providing her justification with the statement “they move from ten to ten.” That was a clear example of interaction type 1.

Concept: base-10 number system
Statement: “They used a 10-based system...”
Validity claim: “They move from ten to ten.”
Example: “Ten, twenty, thirty...”

They continued the conversation. Aida raised another interesting aspect regarding the dissemination of number systems in the history of mathematics: Hindu-Arabic numerals were not well accepted at the beginning in Europe. This added a new layer to our discussion: the sociological approach. Numbers [numerals] are social goods. They are result of social consensus between people who agree on using a particular numeral (and not other) because a number of reasons. Aida was talking about how the Hindu-Arabic numerical system was introduced in Europe, during the Middle Age.

Concept: Hindu-Arabic number system
Statement: “It was upon a time, in Florence, that people did not like those numbers [Arab numbers]”
Validity claim: “because it was very easy to falsify the zero, the six and the nine.”
Example: 6 ↔ 9 [you just have to flip the symbol]

Discussion

The analysis of the dialogues occurred during the session reveal some important aspects related to the MDGs and how adults develop their mathematical literacy.

First, using classic readings in a dialogical way suggests that adult learners are able to discuss and understand formal mathematics. Some theories in Sociology of Education claim that learning is
stratified among individuals according to their social class. Bourdieu (1986) coined the theory of “cultural capital” to explain that certain forms of cultural capital are socially valued over others. For “cultural capital” he refers to a collection of symbolic aspects such as skills, knowledge, type of readings, taste (for books, paintings, etc.), ways to dress, etc. According to him, cultural capital comes in three forms: embodied, objectified and institutionalized. Reading classics may be a symbol of belonging to a privileged social class; hence people from the grassroots “usually don’t appreciate” this kind of readings. Our data suggest the opposite idea: the women participating in the MDGs are enjoying the best readings in mathematics, and they are maintaining meaningful dialogues drawing on such readings.

Moreover, in the 1970s, 1980s, and early 1990s Basil Bernstein published several books analyzing discourses from a social point of view. In the first volume of Class, codes and control (four volumes), edited in 1971, Bernstein distinguished between elaborated codes and restricted codes. According to him, the forms of spoken language are associated with particular positions in the social structure hierarchy. Elaborated codes correspond to formal discourses, distinctive of the “well educated social classes,” whereas “restricted codes” are typical of under represented social classes, using different forms of slang. Drawing on this approach, Paul Willis (1977) wrote an important ethnography suggesting that what children from working class families learn in the school is to be members of their social class, nothing else. Thus, they “don’t appreciate” classic readings because it does not belong to their “cultural capital.” Again, the analysis of the data collected suggests that this interpretation may be wrong.

According to Catherine Snow (2002), the crucial variable to understand an individual’s skills (she said this in respect of reading, but I also suggest the same idea in mathematics literacy) is not their social class, nor their gender; but the amount of times that a particular person has been exposed to high quality texts. In other words, the better the readings are, the better the learning is. When we provide classics to the learners, they use readings that already are high quality (because the scientific community universally claims that these readings are “classic.”) Using the best mathematical readings then, give people the opportunity to be exposed to relevant and important notions in mathematics, hence the level of their talk increases. Our data is consistent with this assumption. During the lesson the participants were able to talk about numeral, quantity, cardinality, number system, base, bi-univocal relationship, etc. All of them are important elements to understand the idea of number. I suggest that similar to work that Snow (2002) undertook with children, an equivalent effect also happens with adults: they learn more and better.

Finally, the analysis of the interactions through the discourse using dialogic talk as a methodological tool provides us the cognitive path that adults follow to understand the mathematical concepts. As Bakhtin (2010) suggested with his work, knowledge is a social product, hence knowing should be understood as a social process. In this lesson participants use dialogue to build on each other’s utterances. Understanding is a final stage; I would say that this “is the ultimate goal after a common path in which everyone supports each other with his/her thoughts, expressed through dialogue.”

References


Behind the Numbers
The Preliminary Findings of a Mixed Methods Study Investigating the Existence of Mathematics Anxiety Among Mature Students

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Abstract
Admitting that one is ‘no good at mathematics’ or ‘hates mathematics’ is a common admission among student cohorts. For mature students who harbour a strong dislike of mathematics, these feelings can be exacerbated when they are faced with having to do an obligatory service mathematics module as part of a programme of study. For some mature students, their dislike of mathematics can be identified as mathematics anxiety. Their experiences of mathematics as a subject throughout their lives are manifold, and depict a variety of emotions, attitudes, and beliefs about the subject. In spite of their experiences with mathematics, mature students demonstrate a persistence – and even a resilience - in respect of their engagement with mathematics. Research on mathematics anxiety is frequently conducted using quantitative methods, in particular measurement scales such as the Mathematics Anxiety Rating Scale (MARS) test or equivalent. However, while these tests reveal a numerical representation for the level of anxiety felt by the participant, there is limited insight available into the context for such anxiety, thereby limiting understanding of the origin of such feelings. To this end, as part of a mixed methods approach, the researcher looks beyond the numerical results of the mathematics anxiety scale to explore the mathematics life histories of three mature students who have taken service mathematics at undergraduate level in Ireland at both University and Institute of Technology (IOT) sectors. This paper reports on preliminary findings of the researcher's data collection.

Key words: mathematics anxiety, mixed methods

In Ireland, a mature student is defined as an adult learner aged 23 or more in the year of enrolment to third level education (CAO, 2016). The profile of the mature student is non-homogeneous; the cohort encompasses diversity in the range of ages, family situations and responsibilities, career experiences, and previous encounters with education (O’Donnell & Tobbell, 2007). Mature students comprise 13% of full-time and 19% of part-time students in higher education in Ireland (HEA, 2016).

Many students at third level are required to complete an obligatory module in mathematics – service mathematics – when they pursue a programme of study, even though mathematics is not
the main discipline (Gill & O’Donoghue, 2005). In the case of mature students, they may not have engaged with academic mathematics for at least 5 years, i.e. since they would have completed their Leaving Certificate⁶ examination or equivalent, and they may be unaware of the mathematics content of their chosen programme until after the programme has commenced (Zaslavsky, 1994). The subject may not be called ‘mathematics’, but instead called ‘quantitative methods’, for example, which may not be evident to a student that it is a mathematics module. A lack of practice can result in difficulties and anxieties around mathematics for students who have not engaged with mathematics academically for a number of years (Betz, 1978).

For some mature students their dislike of mathematics can be identified as mathematics anxiety, defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972: p. 551). To ascertain the existence of mathematics anxiety, measurement scales are commonly used. Such scales involve the candidate reading a list of statements depicting situations involving mathematics and numbers, and expressing their level of anxiety using a Likert-scale approach. The total of the results gives a score for that candidate, which enables the researcher to determine the level of anxiety of the candidate.

The original mathematics anxiety test was the Mathematics Anxiety Rating Scale or ‘MARS’ test (Richardson and Suinn, 1972), which involved third level students completing a 98-item list of statements; however, this test took much time to complete and aggregate (Suinn & Winston, 2003; Hunt, et al., 2011). Variations of the MARS test have evolved over the years to be used with primary school children (Suinn, et al., 1988), and adolescents (Suinn & Edwards, 1982); however, the majority have been developed in the USA with an American audience in mind (Hunt, et al., 2011). In 2011, the MAS-UK (Hunt, et al. 2011) was developed; this emulated Suinn and Winston’s MARS-30 (2003) but was designed for a UK and European audience (Hunt, et al. 2011). It comprises 23 statements, with a Likert-scale range of 1 to 5 to ascertain the level of anxiety of the candidate, with 1 being ‘not at all’ anxious, and 5 being ‘very’ anxious. The minimum score achievable is 23, and the maximum is 115. Hunt and colleagues (2011) identified three groupings of statements within the MAS-UK: mathematics evaluation anxiety (9 items), everyday/social mathematics anxiety (8 items), and mathematics observation anxiety (6 items). Of these three groupings, ‘mathematics evaluation anxiety’ was responsible for the ‘largest share of the variance’ in the MAS-UK scores (Hunt, et al., 2011: p. 462).

While research on mathematics anxiety is frequently conducted using quantitative methods, there is limited insight available into the context for such anxiety, thereby limiting understanding as to the factors that caused such feelings. Qualitative methods, in particular life histories, offer a useful way of exploring the issues throughout a student’s life that may have contributed to their anxiety towards mathematics (Coben & Thumpston, 1995; Golding & O’Donoghue, 2005), or alternatively to their appreciation of mathematics.

The use of qualitative methods to explore negative feelings about mathematics was first documented by Tobias (1978) in the form of ‘mathematics autobiographies’. Briggs (1994) presented the concept of an ‘automathematicsbiography’ to facilitate the writer’s account of their experiences with mathematics, in order that these could subsequently be explored for impressions, feelings and ideas about mathematics. Bloomfield and Clews (1994) used ‘mathematical autobiography’ to identify categories of student experiences, namely ‘influences’, ‘critical points’, and ‘constraints’. Coben and Thumpston (1995) conducted interviews to elicit the ‘mathematics life histories’ of mature students to hear their life stories around mathematics. Golding and O’Donoghue (2005) demonstrated the advantages of ‘topic maps’ for mature students to help with confidence building and problem solving as they approach service mathematics at third level. More recently, McCulloch and colleagues (2013) have asserted the

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⁶ The Leaving Certificate examination is Ireland’s terminal state examination taken when students are typically 17 or 18 years of age (DES, 2016)
The popularity of mathematics autobiographies – particularly oral accounts – in research into individuals’ attitudes, beliefs, and identities in respect of mathematics (McCulloch et al., 2013).

The life history approach provides the researcher with the opportunity to elicit stories about times of significance or change in a person’s life, with a view to exploring how the candidate dealt with that change and moved on from that point. Life history research is particularly suitable for eliciting stories about education and schooling (Munro, 1998; Bold, 2012), as the subjective nature of these experiences is influenced by the individuals and the circumstances that shaped their educational journey (Goodson, 2006). It is also useful in attempting to identify the broader issues surrounding mathematics as a subject that have resulted in the mature student feeling about mathematics as they do, whether positive or negative. To enable a focus on particular aspects of the interviewee’s life, a tailored approach to life history interviews facilitates concentration on focal points in their life, rather than a complete autobiographical account (McAdams, 1993; Plummer, 2001; Drake, 2006; Reece et al., 2010). McAdams’s (1993) offers a practical framework for conducting life story research, allowing a particular focus on nuclear episodes (McAdams, 1993) relating to the theme at hand. In the case of exploring mathematics life histories, interviewees can be asked about their past experiences of mathematics with a focus on the following ‘nuclear episodes’ (adapted from McAdams, 1993):

- their earliest memory of mathematics,
- mathematics at primary school,
- mathematics at secondary school,
- mathematics after school,
- their decision to enter third level education and preparing for mathematics at third level,
- their experience of service mathematics at third level,
- their overall strategy with mathematics – past and present,
- the significance of mathematics to their future career.

These themes allow for points of comparison (Coben & Thumpston, 1995) between the candidates.

A mixed method research design

The approach taken for this research involved a sequential mixed methods approach (Mertens, 2015) comprising a quantitative phase (phase one), followed by a qualitative phase (phase two). The purpose of phase one was to ascertain the level of mathematics anxiety among the mature student respondents. An online questionnaire was compiled (using SurveyMonkey.com), piloted, revised and distributed by email hyperlink with the assistance of the mature student officer or access officer of each of four randomly selected higher education institutions (HEIs) around Ireland, namely 2 Institutes of Technology and 2 Universities. The questionnaire was distributed to a sample of approximately 500 undergraduate mature students who have a service mathematics module as part of their programme of study, and resulted in a response rate of approximately 21% (n=107). Recipients were asked for some personal details (gender, date of birth, discipline of study, year they left school) as well as to complete the MAS-UK test; participants were also given the option of including contact details – email address or phone number – to confirm if they would be interested in participating in phase two of the study.

Phase two involved conducting life history interviews with the intention of eliciting insights into mature students’ individual experiences with mathematics. A total of 20 students (13 male, 7 female) responded to the invitation to attend for interview, with ten each from the Institute of Technology and University sectors. The interviews were semi-structured, with the questions guided by McAdams’s (1993) framework for conducting life story research. The interviews were audio-recorded and transcribed. Each interviewee’s transcript was emailed to them for
verification of the content. Initial analysis of the interview transcripts was guided by McAdams’s (1993) framework for conducting life story research, and focussed on references to each of the nuclear episodes as outlined in the previous section.

**Findings: Quantitative**

Collectively, the candidates presented varying levels of mathematics anxiety as determined through the MAS-UK test. The range of MAS-UK scores among the 107 respondents was from 23 to 94 (Figure 1) out of a potential range of 23 (not at all anxious) to 115 (very anxious) (Hunt, et al, 2001); thus no candidate was coming in as ‘very’ mathematics anxious, the highest level of mathematics anxiety. While the majority of the scores lie within steps 1 to 3 of the MAS-UK (a range of 23 to 69) there is a cluster of 10 students (9.3%) in the range of scores from 82 to 94, demonstrating higher levels of mathematics anxiety.

**Analysis of scores for the 23 individual statements in the MAS-UK**

Closer analysis of responses to the MAS-UK instrument indicated that the statements with the highest proportion of 5s (very anxious) answered by the entire cohort were:

6. Taking a mathematics exam (31%)
18. Being given a surprise mathematics test in a class (27%)
23. Being asked a mathematics question by a teacher/lecturer in front of a class (22%)
3. Being asked to write an answer on the board at the front of a mathematics class (18%).

When the scores for 4 (much) and 5 (very) are combined, the same statements emerge but the order changes, with statement 18 leading with 47%, followed by statement 6 (43%), statement 23 (43%), and statement 3 (28%). When scores of 3 (somewhat), 4 (much), and 5 (very) are

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7Further analysis of the transcripts will be conducted subsequent to completion of this paper.
combined, once again statements 6, 18, 23, and 3 emerge, with cumulative percentages of 66, 63, 58, and 53 respectively.

The common themes within these four statements are the evaluation of one’s mathematical knowledge and, in particular, being singled out to do a mathematics question in front of the entire class. These four statements belong to the ‘mathematics evaluation anxiety’ grouping within the MAS-UK.

At the lower end of the scale were the following situations, with the percentages representing the number of 1s selected among the cohort (1 = ‘not at all’ anxious):

2. Adding up a pile of change (78%)
11. Working out how much time you have left before you set off for work or place of study (74%)
13. Working out how much change a cashier should have given you in a shop after buying several items (73%)
22. Working out how much your shopping bill comes to (67%)
4. Being asked to add up the number of people in a room (65%).

When the scores for 1 (not at all) and 2 (somewhat) are added, the same 5 statements reoccur, but the order changes: statement 2 (91%), statement 4 (89%), statement 11 (88%), statement 13 (86%) and statement 22 (86%). These situations belong to the ‘Everyday/Social Mathematics’ component of the MAS-UK, and are reflective of everyday situations that students would engage with and be familiar with (Hunt et al., 2011).

Focus on the three candidates with highest levels of mathematics anxiety

Among the respondents to participate in the life history interviews, there were clusters of candidates between ‘not at all’ anxious and ‘a little’ anxious (n=6 or 30%), as well as between ‘a little’ anxious and ‘somewhat’ anxious (n=11 or 55%). Three candidates scored higher, with MAS-UK scores of 83, 86 and 94. These represented the students with the highest scores among the candidates.

Analysis of the three highest candidates’ MAS-UK results revealed that four situations were given a score of 5 (‘very’ anxious) by each of the three candidates:

3. Being asked to write an answer on the board at the front of a mathematics class
18. Being given a surprise mathematics test in a class
21. Being asked to calculate three fifths as a percentage
23. Being asked a mathematics question by a teacher/lecturer in front of a class

Further analysis of the situations given a 4 or 5 by the three candidates reveals the following additional situations that feature as ‘much’ or ‘very’ mathematics anxious:

6. Taking a mathematics exam
7. Being asked to calculate €9.36 divided by 4 in front of several people
8. Being given a telephone number and having to remember it
9. Reading the word ‘algebra’
12. Listening to someone talk about mathematics
17. Sitting in a mathematics class
20. Watching a teacher/lecturer write equations on the board
Two of the three candidates did not give a score of 1 (not at all anxious) to any statement. All three candidates gave a score of 2 to statement number 2: Adding up a pile of change. Scores of 1, 2, and 3 were given between the candidates for statement 4: Being asked to add up the number of people in a room. These two statements were the lowest scoring within the MAS-UK test, and are included in the Everyday/Social mathematics section of the MAS-UK.

The findings for the three candidates with the highest MAS-UK scores are reflective of the findings of the entire group; in particular, the statements with the highest scores reflect Mathematics Evaluation anxiety which features as a prominent factor in contributing to mathematics anxiety among this group of students. Similarly, the lowest scores reflect Everyday/Social mathematics anxiety. In order to get an insight into the aspects of the three students’ life experiences with mathematics, the following section explores the findings of the life history interviews.

**Findings: Qualitative**

This section focuses on the three highest scoring candidates in the MAS-UK test, with scores of 83, 86, and 94. The following paragraphs provide a synopsis of each of their life histories with mathematics as guided by McAdams’s (1993) framework. Each synopsis refers to the nuclear episodes, i.e. the student’s experiences of mathematics at primary and secondary school, after school and returning to third level, as well as their strategy for mathematics, and significance of mathematics for their future.

**Mature student 1: James**

(male, aged 37, attending Uni, studying Sociology, MAS-UK score: 83)

At primary level, the basic calculations – addition and subtraction – were not an issue, it was multiplication, division, fractions, and later negative numbers that caused problems. At second level, he was lost in class, and didn’t want to ask questions in class. He felt that the teacher didn’t have time to help him; and he had a perception that the other students in his class were much better than he was at mathematics. He sensed he was falling behind, and in preparation for the Leaving Certificate examination he got extra tuition (‘grinds’) in mathematics. In University his approach to mathematics has been very strategic, in that he is aware of what he needs to pass each component of the mathematics module, and aims to that target. However, he is aware of the relevance of mathematics to real life, and appreciates how great mathematics can be when it makes sense. He does not envisage that mathematics will play a large part in his future career, but is not afraid to try mathematics.

**Mature student 2: Gayle**

(female, aged 38, deferred Science course at IoT, MAS-UK score: 86)

After 6 weeks in term 1 of first year, Gayle deferred her course until the following September because of the mathematics content. Her negative feelings toward mathematics stem from primary school and saying tables in class, standing at the top of the class, and when you got it wrong you had to sit down. Students who knew the answers would shout them out, and she felt left behind, and continually falling behind as a result of this. She was aware that she was in the second lowest class in secondary school for the junior cycle (age 13-15 age group). She felt that the teacher gave most of his attention to the better students in the class, and he didn’t seem to care if the others got the concepts or not. In the IoT she wasn’t aware of any mathematics support available to students. Since she deferred her place, she has been getting extra tuition in mathematics to help her prepare for re-entry to the programme. She enrolled in a course to become an outdoor sports instructor, not realising the sailing element would require calculations of degrees, but she persevered with
that, despite her reservations. She is determined to continue her studies in Science at the IoT, and acknowledges the need for support in mathematics, and will pursue this when she returns.

**Mature student 3: Pat**

(male, aged 34, attending IoT, studying Culinary Arts, MAS-UK score: 94)

Pat’s self-perception is that he was never good at mathematics. His experience of times tables was just going along with the class as they recited the tables; but when asked a question on his own, he would go blank. He liked counting on his fingers, and is comfortable doing that. His approach to mathematics is step by step at a slow pace. He reflects on his experience in secondary school with an element of regret, blaming the teacher for not teaching him. He uses the word panic throughout his interview. In his mathematics module, he does not ask questions as he is anxious about slowing down the class. This results in him not understanding the topic, and anything he did understand being forgotten by the next class. However, he does avail of the mathematics support service and likes the slower, one-to-one pace there. He needs to get closure on a mathematics problem before he leaves the class or support session. That is his approach to successful learning of mathematics. He also expressed anxiety towards accounting, and using spreadsheets. His characterisation of his relationship with mathematics is avoidance if at all possible, but if he has to do it he will make his best attempt.

**Discussion**

Mathematics anxiety exists among mature students at third level, albeit with different levels of intensity, and with varying consequences for students of service mathematics. This mixed method study has recorded both the measuring of mathematics anxiety levels of the mature student candidates, as well as allowing insight into the past experiences that may have contributed to the level of anxiety the students feel at this stage of their lives. It offers a bigger picture in respect of the students’ experiences of and engagement with mathematics to-date and provides a platform for understanding the students’ feelings about mathematics. The analysis of the statements in the MAS-UK combined with the stories of these three candidates reflect the findings of previous separate quantitative and qualitative studies of mathematics anxiety.

The findings show higher levels of anxiety in situations where the student is or has been faced with an examination of their knowledge of mathematics, as well as being in a public situation involving mathematics, typically in front of their peers and the teacher of mathematics. The life history interviews reveal that the three students’ experiences at school contributed to the way they feel about and interact with mathematics as mature students. The effects of what happened in the students’ past experiences with mathematics has had long term consequences for these three candidates, particularly in respect of their confidence and self-efficacy towards mathematics. The effect of this is that they have experienced considerable levels of mathematics anxiety at third level, and particularly in the context of mathematics evaluation. To this end, engagement with mathematics support, as well as peer support, has been significant for these students in both academic achievement and confidence-building.

Less anxiety was reported in everyday situations where the use of numbers and calculation is carried out in a more realistic situation, where engagement with numbers has a relevance to the student. This is reflected in the students’ personal experiences with mathematics and a preference for doing calculations that have relevance to their lives. In spite of their experiences with mathematics, these mature students have demonstrated a persistence - and even a resilience - in respect of their engagement with mathematics.

These findings have presented three different mature student stories with very different attitudes and strategies towards their study of service mathematics. The considerable negativity towards mathematics can lead to avoidance tendencies, as is evident particularly with two of these
candidates. Their stories reveal the importance of support in mathematics – both academic and peer – in order to help boost their confidence in mathematics. While there is considerable support available at third level, this research demonstrates the importance of such support for students with higher levels of mathematics anxiety. In this regard, there is scope at third level to conduct testing to ascertain levels of mathematics anxiety in addition to giving time to students to talk about their experiences with mathematics. It is also the author’s contention that measures be taken to address the concerns of potential students that might consider entering third level, in order that they are aware of what may be involved in service mathematics, and be informed of the levels of support available to help them with mathematics.

Conclusion

The mixed method approach facilitates a means of comparison between the quantitative and qualitative findings, but it allows an insight into the numbers presented in the quantitative approach. McAdams’s framework provides a succinct, but comprehensive tool for the analysis of a person’s life history experiences in a tailored way. In this study, the framework allows both researcher and interviewee to direct attention to the mature student’s experiences with mathematics throughout their life, thereby allowing for efficient data collection.

While the emphasis in this study has been confined to three mature students from the University and Institute of Technology sectors, there is scope to roll out the MAS-UK within all HEIs in Ireland where service mathematics features within programmes of study with the particular intention of compiling a dataset that reflects the prevalence of mathematics anxiety among mature students at third level in Ireland. The researcher contends that this study presents an opportunity to examine the possibility of developing a revision of the MAS-UK to suit the Irish HEI environment, but in light of the context of the mature student.

References


