

Factors influencing the transition to university service mathematics: part 2 a qualitative study

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A qualitative study was carried out by the authors into the influence of affective variables, the role of conceptions of mathematics and approaches to learning on students in the transition to service mathematics at the University of Limerick. The study is a follow-up study to an earlier quantitative study. The studies focus on first year Science, Engineering and Technological Mathematics students. This second part of the research, through the use of semi-structured interviews, aims to gain further insight into the impact of the aforementioned factors on students in their first year of university Service mathematics. This article reports on the consequences of the findings and enables us to envisage the problems that may arise in the future for mathematics education in Ireland.

1. Introduction

This study was conducted as a follow-up to a quantitative study reported earlier (Liston & O'Donoghue, 2009). The research was undertaken at the University of Limerick (UL) to investigate the so-called 'Mathematics Problem' (this refers to students entering third level whose mathematics at school level is insufficient for the demands of their service mathematics courses and careers). Worrying findings from recent reports such as the *Statement on Raising National Mathematical Achievement* (Expert Group on Future Skills Needs, 2008), which highlight concerns about students' quality of work and capacity to engage with problem solving and decision making in mathematics, suggest the need for assessing entering third-level students to address the 'gap' between second- and third-level mathematics.

A study of this nature has not been undertaken in Ireland and findings from this qualitative study, together with those from the quantitative study (Liston & O'Donoghue, 2009), facilitate the authors in determining the strength and depth of the influence of affective variables, conceptions of mathematics and approaches to learning on students studying Service mathematics.

2. Background to the study

There is considerable evidence that students in Ireland encounter many mathematical difficulties in the transition to university. This evidence comes from a number of sources including

diagnostic testing carried out at UL (Gill, 2006) and national reports [National Council for Curriculum and Assessment (NCCA), 2005].

Part 1 of this study (Liston & O'Donoghue, 2009) highlighted some important findings in relation to the factors that influence students in the transition to university Service mathematics. Enjoyment of mathematics and mathematical self-concept were the two affective variables that correlated most strongly with the students' mathematics exam performance. Paired sample *t*-tests revealed significant differences between students' conceptions of mathematics and again between their approaches to learning. Students were found to lean more towards deep approach (DA) learners rather than surface approach (SA) learners and had a more cohesive view of mathematics than a fragmented conception of mathematics (FCM). The authors realize that very small differences will often be statistically significant in such a large sample size as this study ($n=607$) and so the differences observed here may not be practically important. The findings do, however, run contrary to recent reports in Ireland, such as (NCCA, 2005). There was a need, therefore, to further understand and examine the role of these factors in the transition to university by carrying out a follow-up qualitative study. This enabled the authors to assess students' own thoughts and feelings and allowed for further conclusions to be drawn.

This article describes the qualitative study conducted in March and April 2007 and provides details of this study. An analysis of the data gathered is presented and the findings are discussed in detail.

3. The study

The aim of the qualitative study was to both gain a deeper understanding into why the respondents responded the way they did in the quantitative study, and to follow up results obtained from the statistical analysis of that study. The investigation took the form of 15 semi-structured interviews, which allowed respondents to make broader statements about more complex responses than simply agreeing or disagreeing (Rubin & Rubin, 1995).

3.1 The research instrument

Fifteen semi-structured interviews were conducted with five randomly selected students from each of the three service mathematics modules. These modules include Science Mathematics 1 ($n=156$), Engineering Mathematics 1 ($n=139$) and Technological Mathematics 1 ($n=312$). Selection was restricted to those students who had completed the questionnaire in phase one of the research so that conclusions could be interpreted from the same sample in both phases. In a semi-structured interview, the interviewer has a set of open-ended questions prepared in advance but is free to modify their order, change wording or perhaps leave out particular questions, which are deemed inappropriate for a particular interviewee (Robson, 1993). Questions for the interviews originate from the scales used in the quantitative study, as well as from other areas in the mathematics education literature (See Appendix 1).

3.2 Research sample

Stratified random sampling (Cohen *et al.*, 2000) was used to select a sample. This is a two-stage process in which the wider population is divided into discrete groups and a random sample is taken within these groups, the size of each group being determined by the judgement of the researcher. This sample was divided into the three modules/groups; Science Mathematics 1, Engineering

TABLE 1. *Research sample for the qualitative study by degree programme, mathematics module and number of students interviewed*

Degree programme	Service mathematics module	No. of students interviewed
Science Degree with concurrent Teacher Education (<i>PST</i>)	Science Mathematics 1	2
Industrial Biochemistry	Science Mathematics 1	1
Health and Safety	Science Mathematics 1	1
Food Science and Health	Science Mathematics 1	1
Physical Education (<i>PST</i>)	Technological Mathematics 1	2
Technology Degree in the Teaching of Materials and Construction (<i>PST</i>)	Technological Mathematics 1	1
Music, Media and Performance Technology	Technological Mathematics 1	1
Engineering Science	Technological Mathematics 1	1
Mechanical Engineering	Engineering Mathematics 1	1
Computer Engineering	Engineering Mathematics 1	1
Manufacturing Engineering	Engineering Mathematics 1	1
Computer Aided Engineering and Design	Engineering Mathematics 1	2

Mathematics 1 and Technological Mathematics 1 and within two of those three groups (Science and Technological Mathematics 1), they were again divided into teacher education and non-teacher education groups. This was done so as to ensure that pre-service teachers were included in the sample. These pre-service teachers are not central to this specific report. The advantage of this form of sampling is that it guarantees equal representation of each identified strata (Leedy & Ormrod, 2001). In total, there are five interviewees from each module including five pre-service teachers (indicated as *PST* in Table 1 where an overview of the research sample for the qualitative study is provided).

3.3 Data collection

The students selected were contacted via email and were asked if they would be willing to participate further in the research. The author also attended a lecture for each of the three groups to ensure those selected had checked emails and would be willing to participate. One student (an Engineering student) did not want to be interviewed so another student, randomly selected from the Engineering Mathematics 1 module, was invited and agreed to participate in the qualitative study. Once the students agreed to be interviewed, phone contact was made to discuss the nature of the research in more detail, explain what was expected of them and go through ethical issues that needed to be addressed. They were made aware that pseudonyms would be used for all interviewees and for any people named in the interviews. Each interview lasted ~30 min. Interviews took place in the Mathematics Learning Centre in UL and were recorded with interviewee's permission using an IC Recorder.

3.4 Data analysis

This qualitative study has many similar qualities to a grounded theory approach and is often referred to as the constant comparative method (Glasser & Strauss, 1967). According to this premise, the theory may be generated from the data, or, if existing (grounded) theories seem appropriate, then these may be elaborated on as incoming data are played against them.

The semi-structured interviews covered seven sections:

- (1) Background/School Experience;
- (2) Transition to University;
- (3) Attitudes to Mathematics;
- (4) Beliefs about Mathematics;
- (5) Mathematical Self-Concept;
- (6) Conceptions of Mathematics; and
- (7) Approaches to Learning.

This data-gathering instrument or interview plan guided the 15 interviews that took place. All interviews were transcribed using Voice Editor 3 software package and NVivo software was used to facilitate the analysis of the interview transcripts. The data were coded based on a list of starter nodes drawn up for each section of the interview as outlined above. After careful analysis, the nodes were re-categorized into new nodes, which emerged from the data. Such re-structuring of categories provided any confirming or disconfirming evidence of the nodes identified or any relationships between them.

4. Findings and discussion

The findings are laid out and discussed here under the seven sections mentioned above. Firstly, to give some insight into the interviewees, Table 2 identifies their total percentage score on each of the scales in the quantitative study [full details of these scales can be found in Liston & O'Donoghue (2009)].

TABLE 2. Interviewees', each of the three cohorts' and entire cohorts', total percentage scores on the scales in the quantitative study

Name	EM (%)	VM (%)	BM (%)	MSC (%)	CCM (%)	FCM (%)	DA (%)	SA (%)
Science Mathematics 1	65	77	68	64	68	65	62	48
Ron	26	52	70	55	40	62	92	50
Amanda (M)	49	78	63	48	60	80	64	36
Vinny	66	90	83	75	78	48	68	44
Gillian (M)	49	84	60	52	80	72	70	38
Frances	46	66	53	57	73	68	62	46
Technological Mathematics 1	67	78	68	68	71	67	59	50
Donald (M)	84	86	77	72	84	70	78	42
Emily	82	82	80	87	78	64	58	42
Emma	95	96	67	78	91	72	76	42
Greg	73	86	70	73	76	70	52	32
Peter	86	78	73	75	71	60	46	52
Engineering Mathematics 1	76	81	72	71	75	63	59	47
Kathy	82	80	63	77	80	72	52	42
Mandy	67	82	60	72	67	60	60	60
Jim (M)	80	80	43	60	71	78	76	50
Jack	80	84	67	70	78	68	64	60
Shane (M)	71	72	77	60	71	60	Missing [†]	48
Entire cohort	68	79	69	68	71	65	60	49

[†]Shane did not respond to all items on the DA scale so his total score on this scale could not be calculated.

VM = Value of Mathematics; BM = Beliefs about Mathematics; MSC = Mathematical Self-Concept; M = mature student.

Table 2 also shows the total percentage scores obtained by each of the three service mathematics cohorts as well as the entire cohort of students in the sample.

4.1 *Background/school experience*

Students' past experiences were most often attributed to their teachers. Eight of the interviewees made reference to their past teachers. Five of these comments were positive while four were negative (Ron overlaps into both negative and positive past experiences since he blames his teacher for a negative experience at Junior Certificate level but refers to his teacher at Leaving Certificate as very good).

I did have an interest in it [mathematics]. Sometimes it depends on the teacher and if the teacher wasn't very interested and didn't make a big deal out of it. (Donald)

Researchers agree that previous experiences have an onward effect on students who progress to third-level education (McInnis *et al.*, 1995).

When analysing the students' overall past experiences (not just in relation to their past experiences with teachers), there was a mix of positive and negative comments (four of each, respectively) towards mathematics in secondary school or in some cases as early as primary school. Seven interviewees made both negative and positive statements in relation to their previous experience with mathematics. Not surprisingly, perhaps, the students who made entirely negative comments had some of the lowest Enjoyment of Mathematics (EM) scores in the quantitative study (Amanda, Francis and Gillian). The fourth student, Donald, despite his negativity towards mathematics in the past, had a high EM scores (84%) and this may be explained by his interest and enjoyment of the subject at third level. The lowest EM score came from Ron (26%) even though he made both positive and negative remarks about his past experiences.

The four interviewees that made reference to a positive time during their mathematics past credited their positive feelings for mathematics to having an interest in the subject and the importance of understanding applications and practical uses of mathematics.

Em, well it [maths] was fine. Personally I kinda like maths so I like the fact that you're doing something practical and that, so I rather like studying maths compared to other subjects like say science or something like that where it's just rote learning kinda. (Emily)

Interest in the subject is important since one of the factors attributed to underachievement in mathematics secondary education is students' lack of interest in the subject (Del Popolo & Shannon, 1987).

4.2 *Transition to university*

This section of the interview examines the students' transition from secondary school (direct or indirect) to university and questions how students have adapted to mathematics at university. We are interested to know how students have coped with the move to university on a personal level and in particular their feelings towards mathematics now that they are at university.

Four of the ten traditional age first year students (18–20 years old) found it difficult to motivate themselves and adjust to the independent way of university life.

Em its difficult enough because you have to be very motivated yourself even to get out of bed for a 9 o'clock lecture like so! And even with the subject they just give you the information and it's up to you to take it in and study and practice it. (Frances)

TABLE 3. *Traditional students' and mature students' comments about mathematics at university*

Comments	Traditional students	Mature students
Number making positive comments	5	4
Number making negative comments	3	0
Number making both positive and negative comments	2	1

Four of the five mature students (over the age of 23) mentioned the advantages of completing access or foundation courses before making that transition to university.

I thought it'd be harder but it actually wasn't that bad. I did a PLC course¹ for two years so I suppose that was pretty full on. Like we had 30 plus hours a week. It was almost school hours but not at all like school. So I was used to very full non-school days. (Amanda)

Mixed feelings towards mathematics at university were evident from the interviews. Table 3 divides the sample into traditional and mature students and categorizes the findings as either positive, negative or a mix of both positive and negative comments in relation to mathematics at university.

Students who had positive or mixed feelings towards studying mathematics at university usually studied mathematics at higher level² in secondary school. It is difficult to draw any conclusions from this since the sample size was small ($n = 15$) and there were eight higher level students in comparison to seven ordinary level students. However, it was interesting that two of the three traditional students with negative feelings towards mathematics at university also studied higher level mathematics and are now studying Engineering. They both mentioned that they find the lectures difficult to follow. Interestingly, only one of five of the traditional students with positive feelings towards mathematics at university did ordinary level mathematics at secondary school, all others had completed higher level mathematics. The previous level of study certainly appears to have made an impact on their attitude or feelings at university.

Well I definitely find it very beneficial that I've done Higher Level [mathematics] because I think say in some lectures like while I might find it easy to keep up with them and eh, really manageable like sometimes you'd stop for a minute and think jeez if I hadn't done this in secondary school like twud actually be hard enough to grasp onto and to keep up. (Emily)

This finding is not surprising since the quantitative study (Liston & O'Donoghue, 2009) revealed that the grade a student achieved at university was strongly related to their previous academic performance (as measured by the level of mathematics studied at school and result achieved).

Four of the five mature students expressed positive feelings about mathematics at university. Jim mentioned both positive and negative experiences with mathematics at the third level. His low exam result of 30% in the first semester service mathematics examinations possibly contributed to this and

1 Post Leaving Certificate (PLC) courses are full-time 1 year programmes of integrated education, training and work experience provided in schools and colleges outside the third-level sector to prepare participants for employment or further education/training, and develop the skills needed for specific occupations.

2 There are three levels of mathematics in the Irish school examination system with the highest level referred to as Higher (often referred to as Honours), a lower level referred to as Ordinary (often referred to as Pass) and the lowest level that can be taken is called Foundation.

he later makes reference to this grade as something that may have affected his confidence. All other mature students scored 56% and above on the end of semester exams.

Four traditional students, three of whom expressed feelings of dislike towards mathematics at university and one of whom expressed a mixture of positive and negative comments, blamed their lecturers.

I just don't understand the teacher [Laughs] ... Yeah like it's a big lecture hall so you can't really ask much questions. They just kind of lecture you all the notes. (Kathy)

Previous studies have assessed the impact of lecturers on their students and, in particular, the consequences of a mismatch between student and lecturers views on teaching (Holton, 1998). A major factor in the difference between student and lecturers' is the importance students give to the explanation of unfamiliar material (Maunder & Harrop, 2003). However, it should be noted that some students in this study with negative feelings believed that their lecturer offered too many explanations and in-depth history behind the mathematics and not enough concrete examples in the form of questions.

... I find the lecturer, I think he talks too much of like the philosophy of maths and how much ... I dunno I think he's in awe of it rather than actually sitting down and saying, 'this is what you have to do', but he doesn't. He says, 'It might mean this or it might mean that, sure maybe it mightn't mean anything' and you're going 'that's not helping, thank you'. (Amanda)

In general, students seem to prefer the smaller learning environments which they were accustomed to in secondary school.

4.3 *Attitudes to mathematics*

Enjoyment and value of mathematics are two factors that motivate students to undertake a task or activity (Pintrich & De Groot, 1990). In the quantitative study conducted 6 months prior to these interviews, it was found that, over the whole cohort, students tend to value mathematics more than they enjoy it; although Table 1 shows that this was not true of all students in this sample. Further insights were gained into students' attitudes towards mathematics from this qualitative study.

Interviewees were questioned on the relevance of mathematics to their chosen career. Their answers showed that understanding how mathematics can be applied in their chosen careers is important for them in seeing the relevance of studying mathematics at university. Studies [such as NCCA (2005)] highlight the benefits of making applications in mathematics to promote understanding.

It appears that students seem to enjoy mathematics more at university level than in school and again they stress the ability to see its uses and how it applies to both their lives and future careers. Two students (both engineers) mention the fact that mathematics is enjoyable when you understand it but not so much when you have to 'learn-off' something in mathematics.

It's grand when you understand everything but then when you're just learning off things you don't understand it's not that enjoyable like. Even though you'd find ways to solve it and things like that, it's not always that enjoyable either. (Shane)

For not the first time, the teacher is mentioned by three interviewees as a factor in whether mathematics is enjoyable or not. In secondary school, for example, Donald felt he had come across poor teachers who made it difficult to enjoy mathematics:

... it was just a case of people can be really good at maths and not be a good teacher and then there's people who can be really ok at maths and a good teacher. Good at teaching, at getting it across and I don't think she was that good at getting it across. (Donald)

The role of the teacher seems of particular significance at secondary school and may have something to do with the fact that additional support from various sources is available from most higher education institutes in comparison to having only one teacher at secondary school. The traditional method of ‘talk and chalk’ teaching is not sufficient to stimulate interest and enjoyment for students and unfortunately it is still a very widely used approach to teaching mathematics (NCCA, 2005).

The general consensus when asked about the value of mathematics is that mathematics is most relevant or important for engineers. Most students could see a connection between the mathematics they are studying and their future careers. Frances is an exception to this. Over the course of the interview, it was clear that she did not have any positive experiences with mathematics and could not see why she was studying it at university. Her lower than average total percentage value of mathematics score (66%) in the quantitative study concurs with such findings. When asked if she thinks mathematics will be valuable in her future career she said:

Not the stuff we’re doing no. Not the stuff I’ve seen in college anyway, no. (Frances)

Similar to a statement on the questionnaire in the quantitative study, students were asked if they think mathematics has contributed to science and other fields of knowledge. Again, the findings support that of the quantitative study with all interviewees agreeing that it has made significant contributions. However, the interviews highlight that most of these students are unsure of how or where the contribution has occurred. Five students offered suggestions in relation to physics and there is some mention of formulas and theories but no concrete examples were offered and a great degree of uncertainty was evident.

I think it has a contribution. I’m not quite sure what is and I couldn’t talk about it but I’m sure it has a contribution. (Emma)

4.4 *Beliefs about mathematics*

We were concerned with broadening our understanding of students’ beliefs about the nature of mathematics. When asked their opinion on the importance of procedure in mathematics, they were mostly in agreement (with the exception of three interviewees) that procedure is very important for learning mathematics.

It’s very important cause you know if you don’t know what it is you’re doing you’ll get frustrated. You’ll get sick of it and you’ll feel like ‘why am I doing this? I can’t do it, I’m not able to do it, I should be doing easier questions’. Unless you’re taught how to go about doing a question you’re only going to get frustrated and bogged down with trying to do it and not being able. (Greg)

While there is a certain amount of procedural knowledge necessary for mathematics learning (Hiebert & Carpenter, 1992), the value students put on it could have detrimental affects for their learning. There is also a feeling among some of the students that mathematics problems should be solved routinely in a matter of minutes. Only four students said they would persevere with solving a problem. Four students said they would get help while the remaining five students, when asked if they would spend time working out a question, said they would give up or not work on a problem on their own. The following statement from Shane highlights a lot about his beliefs about mathematics and emphasizes the fact that he thinks mathematics problems should be solved quickly:

Once I was getting through it like usually the longest I’d spend on a maths problem might be only five or ten minutes. If you hadn’t got it out by then like there’d be something wrong like. (Shane)

This comment adds weight to the view in the literature that students believe solving mathematics is a routine procedure done in a minimal amount of time (e.g. Schoenfeld, 1989).

The findings also suggest a lack of consistency between some students' beliefs about mathematics and their idea of best practice for learning and understanding mathematics. There seemed to be a contradiction in some of the students' responses. In the case of Mandy, she talked about the need for procedure and routine in mathematics but also recognized the importance of being able to make applications. Jim's response could be interpreted in two ways. He feels that knowing the procedure is important and that 'you can't miss steps'. It would appear from this statement that Jim believes in a SA to learning, i.e. a student who rote learns the steps of a method (findings from the quantitative study, as indicated in Table 2, support this given that Jim had the lowest total percentage belief about mathematics score of 43%). However, he follows up the sentence explaining the importance of understanding and making practical applications:

Like this is the whole point of the lecturers in the lectures, will teach you why you are doing this is where it comes from. But I mean if you're doing maths for the sake of just getting an answer at the end and you don't see the process behind it you'll never use it in a practical application like. (Jim)

On the other hand, Jim failed his first semester exam and may now believe that understanding is important, particularly if you want to apply mathematics, but he also believes that in order to 'do maths' you have to know the procedure and do all the steps. Indeed, the complex nature of the connection between beliefs and practice has been identified particularly in relation to teachers of mathematics (Beswick, 2007).

4.5 *Mathematical self-concept*

Students' mathematical self-concept was assessed in the interviews by questioning their ability to trust themselves to work independently and by asking them about their confidence in mathematics at university. Findings imply that the students only trust that their answers are correct in mathematics when a familiar procedure or method is part of the question. As one student claims,

Well the first few times I'd check it and see but after you use the same formula or whatever you kinda know that if it looks kinda right or d'you know? (Mandy)

In relation to confidence, it was found that most students felt their confidence has improved since secondary school. Students in this study attributed good grades to increased levels of confidence.

Confidence levels were not all high across the sample, however. Students often attributed poor grades to their low levels of confidence. This is particularly true for Frances whose lack of knowledge of mathematics in contrast to her knowledge of science subjects seems to have contributed to her poor confidence.

In comparison to others around me I suppose as well and like if I compare how I am at maths to my other subjects I have very little confidence in maths. (Frances)

4.6 *Conceptions of mathematics*

The quantitative study assessed students' conceptions as either 'fragmented' or 'cohesive'. Fragmented statements focus on parts rather than wholes while cohesive statements concentrate on the whole picture rather than just constituent parts. This qualitative study aimed to get a further insight into students' conceptions.

In order to gain a deeper understanding of how students perceive mathematics, they were asked to define it. Numbers, formulas, procedures and problem solving were mostly mentioned (10 students) in the descriptions given. These terms are used frequently throughout the interviews and are an obvious part of student learning. This is despite the fact that in the quantitative study, 12 out of the 15 interviewees had higher cohesive conception of mathematics (CCM) scores than FCM scores (see Table 2). A possible reason for this contradiction between the quantitative and qualitative study is that students may not have been as honest in filling out the questionnaire as they may have been in a one-on-one interview setting and so may have ticked the boxes that they felt would reflect well on them.

One interviewee proceeded to summarize the content as his definition of mathematics:

Its adding, subtracting, differentiation, integration. It's everything really. There's so many; it's everything; no it's impossible to define! There's so much in it like I don't know how you'd narrow down into just one definition. (Peter)

This definition could have many educational implications for society in general, i.e. the general public's perception of mathematics education, as it is believed that mathematics education cannot be built around some specific subject matter if it does not want to lose its relevance (Khait, 2005). In that paper, there is a call for change from such a topic-oriented mathematics education. In other words, content and specific topics should not be the most important aspect when offering a description of mathematics and instead it should become a habit of mind.

In the quantitative study, it had been found that students lean slightly towards a cohesive rather than fragmented concept of mathematics. However, the interviews aimed to provide more evidence of their conceptions of mathematics. Students were asked what they believe to be the most important aspect when learning mathematics that led to a range of responses, mainly focussed on their approaches to learning. Perhaps, this was a shortcoming on the researchers' part who may have assumed too much in relation to students' understanding of the term 'conceptions'. For this reason, the findings from this question will be discussed in the next section of this article together with approaches to learning.

4.7 *Approaches to learning*

As mentioned, a range of responses to what students believe to be the most dominant feature or most important aspect when learning mathematics led the authors to categorize the findings (see Table 4). One student, Shane, felt at the time of the interview, passing the exam was most important but he also expressed his desire to solve and apply mathematics. Therefore, he was categorized into both 'application' and 'pass exam' categories.

On a positive note, the importance of understanding was most mentioned by four students as being essential for learning mathematics. This was followed by the importance of procedures/learning-off in mathematics and the ability to make applications to, and see the relevance of, the mathematics being studied. Not surprisingly, one of the two students who chose reproducing material as the most dominant aspect when learning was Frances.

Oh em I suppose I would try and understand it but in a lot of cases I wouldn't be able to understand it so I'd just; I'd probably learn off a way of how to do a certain thing. I'd probably be doing things in questions that I wouldn't understand why I'm doing it but I'd still be doing it anyway. (Frances)

In the quantitative study, Frances has one of the lowest mathematical self-concept scores (57%), as shown in Table 2, and she expresses negative feelings towards mathematics throughout the interview.

TABLE 4. *Categorizing students in terms of conceptions of mathematics/approaches to learning*

Category	No. of students
Practice	1
Understand	2
Procedure	3
Interest	1
Reproduce	2
Application	3
Relax	1
Pass exam	1

She also had a lower CCM total percentage score (66%) than FCM total percentage score (76%). She did, however, have a higher than average in DA to learning score (62%) and her SA to learning score (46%) was also below the average of the whole cohort. Again, a contradiction is highlighted between the student's results from the questionnaire and what she says in her interview. The statements, in the Approaches to Learning scale used in the quantitative study, focussed on general approaches to learning and were not specific to mathematics. This may explain why Frances' scores on the DA and SA scales were more positive than her feelings expressed in the interviews with regard to her approaches to learning mathematics. The other student, Kathy, who focuses on reproducing material in her learning of mathematics, had some positive scores in the quantitative study. Her CCM score was very positive (80%). However, her FCM score was also quite high (72%). Kathy conveyed in her interview the difficulties she was having with lectures and the fact that she cannot understand the material. It is not surprising, therefore, that while both Frances and Kathy would like to be able to understand the material, they often settle for reproducing or learning off to pass the exam.

Two other students, Amanda and Ron, had higher FCM total percentage scores than CCM total percentage scores (see Table 2). Amanda was the student in Table 4 who claimed that the most dominant aspect for her when learning mathematics is to practise questions. Ron claimed that the 'procedure is the sort of be all' when it comes to mathematics and his very low CCM total percentage score of 40% as well as his relatively high (60%) FCM score in the quantitative study highlights his somewhat narrow view of mathematics. As mentioned earlier, Ron also had a noticeably low EM score (26%). Research has shown that students' attitude to mathematics is enhanced, or otherwise, by their conceptions of the subject (Philippou & Christou, 1998) which may explain both Ron's low CCM score and his very low EM score.

The interviewees were queried on whether they felt their conceptions of mathematics influence how they study it. Again, we are unsure as to whether the students understand the term 'conception' or not. However, two students did comment on their increased awareness of mathematics applications when approaching their study of certain topics in mathematics.

Further findings in the interview imply, and not for the first time, that some students' conceptions of mathematics are not always consistent with the approach they adopt for studying. Greg is a case in this point. When asked what he felt the most important aspect was for him when learning mathematics he said:

Eh so long as I get a good understanding of what it is I'm expected to do in a curricular section of maths or whatever. So long as you get a good understanding early in it and I know how it is

you're supposed to go about taking a question on then I'd be happy enough that I'd be able to do it like. (Greg)

In the follow-up questions, he then goes on to explain how he approaches his study of mathematics.

Well if there's formulas involved, learn the formulas and know what it is you need to put into formulas or get out of it. Then if there are not formulas just practice the questions basically. (Greg)

He mentions the importance of understanding for effective learning yet the bulk of his comments are focussed on procedures, formula and repetition to study mathematics at university. Such an insight into Greg's approaches to learning is somewhat surprising given his low surface total percentage score of 32% in the quantitative study, although his DA to learning mean score of 52% is also among the lowest of the students interviewed (see Table 4). Such low surface and deep scores may suggest use of procedural approaches to learning (Case & Marshall, 2004). Possibly Greg lies somewhere between a 'surface' and 'deep' learner leaning more towards a 'procedural deep' approach where his intention is towards understanding but his strategy does not include concepts.

The complexity of learning mathematics is evident from Greg's comments and indeed other students' comments. His secondary school experience seemed to be based around formulas while some of his university mathematics experience has broadened his mind. As a pre-service mathematics teacher, Greg, as well as Emily, has two mathematics modules at university in the first year. One module is based on secondary school mathematics while the other module is more abstract and involves more logically thinking. When explaining how he copes with this 'abstract' mathematics module at university he says:

Well I got through the first semester anyway and the second semester I found it a small bit easier. Because now that I've gotten used to the type of maths that it is, its kinda just more based on using thought rather than actually formulas and things. (Greg)

However, the type of approach to learning that students adopt in this study focuses predominantly on exam papers, practice and repetition of questions (10 interviewees). According to one engineering student:

Exam papers. Constant exam papers. I'd almost throw away the notes and throw away that book because I'm very disheartened with it! [Laughs]. (Jim)

These are mostly procedural or surface strategies that quite often fail to develop the students' conceptual understanding. Rote learning is detrimental to deep learning and it can interfere with students' procedural ability while also preventing an understanding of mathematical concepts (Porter & Masingila, 2000).

Students (five out of the fourteen asked) found their lecturers to be very knowledgeable and have an extensive understanding of the background to the mathematics they teach. However, this is not always what the students describe as beneficial. Ron, despite his extremely high DA to learning score (90%) in the quantitative study, shows in the following statement that he is very surface focussed.

It's not the way; he's not teaching us from the blackboard say. He's not saying, 'this is it, this is how you do it'. He's trying to explain the maths to you and what it's about as opposed to doing it. Eh it's not great cause just show me how to do it like. (Ron)

As mentioned earlier, the approaches to learning scale in the quantitative study was in relation to general learning as opposed to mathematics learning specifically that might explain why Ron's DA score was so high and his above statement, referring to his preferred approach to learning mathematics, is very much on a surface level. In addition, it seems that students in this sample relate understanding in mathematics to being able to carry out procedures and fill in formulas. This may not be the case with all their subjects and so did not come to the fore in the quantitative study. Such a reliance on spoon-feeding the mathematics and rote-type learning is not surprising since it is very likely that this is the type of teaching that they received in their secondary school education. Several reports (such as four) have shown that many students coming from Irish secondary school mathematics classrooms often have little if any understanding of what and why they are doing mathematics and the focus of teaching in Ireland is on memorization and routine performance.

There also appears to be a mismatch between lecturer and student expectations of each other. Many students struggled to benefit from lectures as they had difficulty in understanding the material. There are mixed views on the impact of lecturers on students' approaches to learning. While some interviewees find lecturers very approachable, they allow questions to be asked and are very helpful; others found the large lecture setting off-putting and did not feel lecturers were approachable. They seem to prefer tutorial or small group settings similar to school. Consider two contrasting statements:

Well you know they're just you know they're so open to questions; they don't mind you asking a question. They don't make you feel dumb no matter what you ask them. (Gillian)

Like I think there's very little student-teacher involvement and lecturers like. Some lecturers will have time for ya like, other lecturers won't. They'll walk into the lecture theatre; they'll put up their acetates and explain them and that'd be, 'cheers thanks very much. Goodbye'. And they'll walk out like so I kind of think that; I don't really like it. I prefer going into a tutorial rather than going into a lecture like. (Peter)

This disparity may be blamed on a number of factors including inadequate preparation at secondary school level, widening of access to higher education and recruitment of staff to universities based on research activities rather than teaching abilities and commitment (Lawson *et al.*, 2003).

5. Conclusion

Based on studies carried out by researchers in other countries, and by the authors, it is clear that attitudes, beliefs, mathematical self-concept, conceptions of mathematics and approaches to learning are crucial areas in mathematics education and need attention in an Irish context. A greater understanding of the impact of such variables on students in the transition to university service mathematics is an important outcome of this qualitative study. A number of key insights were discussed in this article including:

- the role of the teacher and teaching strategies on students' enjoyment of mathematics at school;
- students difficulty in identifying how mathematics is valuable in everyday life and careers;
- a belief among some of the students that mathematics should be solved routinely in a minimal amount of time;
- students, in the main, were not confident studying mathematics that was not familiar to them and achieving good grades helped to boost their mathematics self-concept; and
- a reliance on procedures and surface-type approaches to learning such as repetition of questions and identification of trends in exam papers. Students often expect lecturers' teaching techniques to

reflect these approaches, many preferring tutorial settings where questions are run through in a rote-like manner. Inconsistencies also appeared between their conceptions of mathematics and how they go about learning.

Our findings suggest, among other things, that efforts be made to alter the teaching strategies currently being used in many Irish mathematics secondary school classrooms (and indeed at higher education level) in order to ease the transition to university mathematics and improve the future for mathematics education. The impact of affective variables, conceptions of mathematic and approaches to learning must be brought to the attention of both in-service and pre-service mathematics teachers, to make them aware of the influence of such factors on not only their mathematics learning but also that of their students.

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Appendix I

Qualitative Interview Schedule

Background/school experience:

- How did you find studying mathematics at secondary school?
- How would you best describe your feelings towards mathematics in school?
- Was the grade you achieved for your Leaving Certificate what you expected?
- Did you intend on studying mathematics after school?

Transition to university:

- In general, how have you found the transition from secondary school to university?
- How do you feel about mathematics now that you are at university?
- Were you aware that mathematics was part of your degree programme?
- Would you study mathematics if given the choice?
- Do you attend lectures and tutorials regularly?
- Are they helpful?
- Do you prepare in advance?
- Do you ask questions in lectures/tutorials?
- Do you see any relevance of the maths you study to your degree course?
- How much time per week do you spend on your maths?
- Do you use the Mathematics Learning Centre?

Attitudes towards mathematics:

- Did you enjoy studying mathematics at school? Do you enjoy studying mathematics at university?

- How valuable do you think it is in everyday life?
- Will it be valuable in your future career?
- Do you enjoy going beyond the assigned work and trying to solve new problems in mathematics?
- Do you think mathematics has contributed to science and other fields of knowledge?
- *Has your attitude to mathematics changed from when you started university to now?*

Beliefs about mathematics:

- Were you encouraged to work on maths problems in school?
- Would you spend much time now trying to solve a mathematics problem?
- How important do you think it is to be taught the correct procedure in mathematics?
- *Are your beliefs about mathematics any different now to what they were when you started university?*

Mathematical self-concept:

- Do you trust that your answers are correct when doing mathematics questions/problems?
- How confident do you feel about your mathematical ability at university?
- Were you confident about maths at secondary school?
- *How confident do you feel about your mathematical ability now that you have almost a year done in university?*

Conceptions of mathematics:

- How would you define mathematics?
- Do you see any connection between mathematics and everyday life?
- What do you consider to be the most dominant feature of learning mathematics?
- *Has your view of mathematics changed over the course of the academic year?*

Approaches to learning:

- Do you think this view of the dominant feature of maths influences how you study?
- What is your main motivation for achieving good grades in mathematics?
- How do you achieve these grades?
- Do you think you understand most of the maths you are studying?
- *Is your approach to studying different now to what it was when you first began university?*

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