Service Mathematics in Irish Universities: Some Findings from a Recent Study

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Abstract

In this paper the authors report on a qualitative investigation into service mathematics carried out in Irish universities against a backdrop of major concerns nationally and internationally embodied in the so-called "Mathematics problem". The enquiry involved a close inspection of how service mathematics is perceived, planned, delivered, evaluated, assessed and experienced by both lecturers and students in selected service mathematics courses in all seven Irish universities. Murphy (2002) used Brousseau's concept of didactical contract to uncover the implicit contract present in Irish second level classrooms. The authors emulated this work to discover the hidden learning contract in university service mathematics lectures in Ireland. Major outcomes of the study include insight into the nature of the didactical contract at work in the service mathematics courses surveyed, and the development of a preliminary characterisation of service mathematics in Irish universities. Service mathematics is also an issue for adult mathematics education and impacts on it.

Keywords: university mathematics, first year, pre-requisite knowledge

Introduction

It is generally acknowledged that adult mathematics education (AME) is not well conceptualised in the research literature. However, there has been progress in this regard as evidenced in the work of researchers, such as, Coben (2006), FitzSimons, Coben and O'Donoghue (2003) and Wedege, Benn and Maaβ (1999). Indeed, it is clear from the work of FitzSimons et al. (2003) that a broad view of adult mathematics education is accepted and includes, inter alia, "specialized mathematics and service mathematics (as in higher education), school mathematics, vocational mathematics" (p. 117).

The authors, who are based in the Mathematics Learning Centre (MLC) at the University of Limerick (UL) have a deep professional stake in service mathematics. Service mathematics is one of those crossover areas between mathematics, mathematics education and adult

mathematics education and is grossly under-theorised and under-conceptualised. As researchers in AME we should be engaged in service mathematics research for the following reasons:

- It is identified as being under the umbrella of AME;
- It is under-theorised and under-conceptualised;
- Elucidation of the nature of service mathematics and its practices can contribute to improvements in AME;
- Considerable numbers of adults engage in service mathematics courses around the world having entered through a variety of routes (e.g. as adult returners, mature students entering via successful Access, Bridging or Transition programmes, direct mature student entry);
- Service mathematics is an academic environment that needs to be better understood because it impacts on significant numbers of adult learners.

The importance of service mathematics for AME is captured and highlighted by the situation at the University of Limerick which is by no means unique in this regard. Adult learners of mathematics (e.g. mature students, access students) comprise a significant group of the student service mathematics population in the University. Fifty-one mature students were admitted to first year undergraduate programmes in 1999-2000 and this number rose to 155 in 2004-5. A total of 474 mature students were registered in UL in 2004-05 (Callaghan, 2005). This number rose to 614 in the subsequent academic year (Coveney O'Beirne, 2006). Most degree programmes in UL (with the exception of the humanities) contain some mathematics modules, so many of these mature students will have mathematics throughout their study.

The UL Mathematics Learning Centre provides support for all students participating in mathematics intensive courses. A drop-in facility is available for 22 hours a week and support tutorials are provided for any mathematics modules where students encounter difficulties. In the larger of these groups, mature students are provided with their own support tutorials. In 2005-6 143 mature students attended support tutorials provided by the Mathematics Learning Centre specifically for mature students. One hundred and eighteen tutorials (44% of all support tutorials) were provided and a total of 909 attendances were recorded. Thirty-seven percent of attendances at support tutorials were by mature students. They represent 22.3% of all students participating at these tutorials. Many mature students also attended the drop-in facility provided by the centre but numbers for this are not available.

The study reported in this paper involved a close inspection of how service mathematics is perceived, planned, delivered, evaluated, assessed and experienced by both lecturers and students in selected service mathematics courses in all seven Irish Universities. Murphy (2002) used Brousseau's concept of didactical contract to uncover the implicit contract present in Irish second level classrooms. The authors emulated this work to discover the hidden learning contract in service mathematics courses in Irish universities. Major outcomes of the study include insight into the nature of the didactical contract at work in the service mathematics courses surveyed, and the development of a preliminary characterisation of service mathematics in Irish universities.

The study reported in the following paragraphs is one of three unique studies (in the Irish context) that were conducted by Gill (2006) between 2001 and 2006. The study was conducted against the backdrop of the so-called Mathematics problem in Ireland and treats service mathematics as an embodiment of the problem in Ireland. This paper elucidates the problem, describes the study including methodology, data collection and analysis, and summarises the

findings with a special focus on the didactical contract in service mathematics courses and the nature of service mathematics.

The Mathematics problem

The so-called Mathematics problem as it is styled in the United Kingdom (UK) research on mathematics education encompasses issues in the transition from school mathematics to university service mathematics and beyond. The Mathematics problem and variants of the problem in western societies have been the subject of widespread debate and concern internationally at a time when there has been a major debate on mathematics education at all levels (e.g. NCCA, 2005; Smith, 2004; PISA, 2003; Engineering Council, 2000; TIMMS, 1997; IMA, 1995; LMS, 1995; NCTM, 1991).

At present there is widespread concern among university academics in many countries (e.g. Australia, United Kingdom) about the poor level of mathematical preparedness of first year undergraduates in mathematics intensive courses. Research shows also, that the problem is not just that some students are *under-prepared* but that even students with good School Leaving Certificate/A-Level grades struggle with even the most basic aspects of mathematics (NCCA, 2005; LMS, 1995).

Added to this problem is the fact that many believe that not only are students under-prepared, but that there is also a decline in standards in school mathematics. In this regard, for example, there is evidence based on a study of data at Coventry University from 1991 to 1995 to suggest that there has been some grade dilution over those years for students entering university (Hunt & Lawson, 1996). There are concerns that this under-preparedness will have serious short and long-term consequences not only for individual students (i.e. failure and dropping out (O'Donoghue, 1999)) but also for the professional reputation of various universities and for the economic progress of a country (Flynn, 2005; LMS, 1995). There are fears in the UK that a drop in the level of the mathematical proficiency of undergraduates will lead to them falling behind their peers in other countries and, as a result, the country itself will have to rely on others for inventions and developments (Smith, 2004; LMS, 1995).

The Mathematics Problem in Ireland

A collection of descriptions of the Mathematics problem has been assembled in Ireland by O'Donoghue (2004) and includes the following:

- Mathematical shortcomings of entering students;
- Mathematical deficiencies of entering students;
- Pre-requisite mathematical knowledge and skills;
- Mathematical preparedness/under-preparedness;
- Mathematics at the school/university interface;
- Issues in service mathematics teaching; and
- Numeracy/Mathematical literacy.

These are overlapping descriptions and for the purposes of this research the authors focus on issues in service mathematics teaching and the impact of the Mathematics problem on adults learning mathematics in Irish universities.

The problem of mathematical under-preparedness has been reported throughout the higher education sector in Ireland over many years with reports from universities and institutes of technology (Cork Regional Technical College, 1985; Hurley & Stynes, 1986; O'Donoghue, 1999). The concern for a drop in standards and inadequate preparation extends as far back as 1984 when research carried out in Cork Regional Technical College (Cork RTC) drew attention to the problem of the poor mathematical grounding of their first year students. The authors concluded that the incoming undergraduates were deficient in basic mathematics. In the following year, Hurley and Stynes (1986) carried out a similar investigation in University College Cork (UCC) with comparable results: their first year students demonstrated poor articulation of basic prerequisite mathematical knowledge.

Also in the late 1980's in the National University of Ireland at Maynooth (NUIM) and more recently in Dublin City University (DCU), it became apparent that students were having the same difficulties in mathematics as students elsewhere in Ireland. Academic staff initiated diagnostic testing to establish where the weaknesses lay and continue this process to the present day.

Due to mounting concern in the Department of Mathematics and Statistics at the University of Limerick (UL), a study entitled *An Intervention to Assist 'At Risk' Students in Service Mathematics at the University of Limerick* was undertaken to gauge the degree of mathematical under-preparedness of first year undergraduate students in mathematics intensive courses. Mathematics lecturers complained that students displayed:

- Lack of fluency in basic arithmetic and algebraic skills;
- Gaps (or in some cases absence of) in basic prerequisite knowledge in important areas of the school syllabus e.g. trigonometry, complex numbers, differential calculus; and
- An inability to use or apply mathematics except in the simplest or most practised way (O'Donoghue, 1999, p. 3).

A pilot study (O'Donoghue, 1999) carried out in 1997-8 suggested that up to 30% of incoming students were *at risk* and would need supplementary help to complete first year successfully. Evidence from this study and a similar study carried out the following year convinced the author that the problem would persist and take on a permanent disposition. This is particularly pertinent in the area of adult mathematics education as many of these students were mature, had not studied mathematics for many years and had presented with significant gaps in their mathematical knowledge.

Many reasons have been put forward to elucidate why things have gone wrong or why this state of affairs in mathematics education exists in Ireland. These include:

- Government policy;
- The Points system for entry to higher education;
- Changes in the Irish second level system; and
- Large class size in higher education institutes.

The existence of the Mathematics Problem was one of a number of contributing factors leading to the establishment of a Mathematics Learning Centre at the University of Limerick in 2001. Since then the Centre has been active in the support of students, including adults engaged in service mathematics, and in researching issues in this area.

Some conceptions of service mathematics

Although service mathematics has not been formally defined in the literature, we presuppose that it refers to degree courses where mathematics plays a part, be it small or large, but is not the main focus of the students' studies. The organisation of mathematics teaching/education in the Irish higher education sector can be seen in Figure 1.

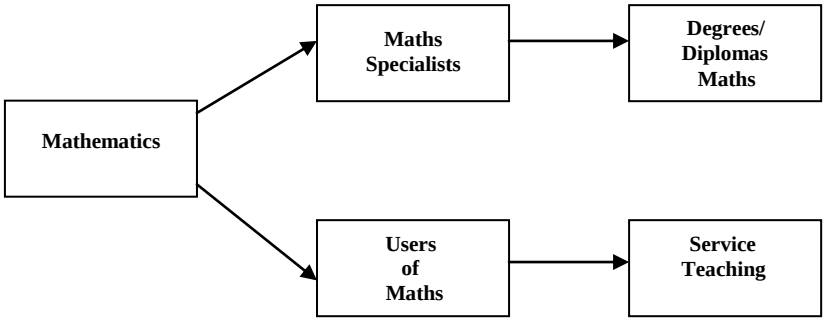

Figure 1. Mathematics Teaching in Higher Education (O'Donoghue, 2002)

Throughout this paper, the authors distinguish between mathematics specialist students and service mathematics students. Those pursuing careers/degree courses in mathematics fields are referred to as mathematicians and mathematics specialist students.

While it was once the case that service mathematics solely referred to engineering mathematics, this is no longer true. Chevallard (1989, p. 52) stated "… the empire of mathematics is steadily spreading and keeps encroaching on domains which until recently had remained foreign to its influence". Today, all professions have varying requirements for the knowledge and use of mathematics skills, with O'Donoghue (1999) correctly predicting that in the 21st century professionals would require higher levels of mathematical proficiency than ever before.

Kent and Noss (2001) ask the question: what is mathematical knowledge? There are, they claim, different perceptions depending on the domain of each profession (i.e. science, engineering). They indicate that this occurs because each person sees a different purpose for mathematics, one that is relevant to their own particular realm. For example, the IMA (1995) assert that engineering mathematics is not simply pure mathematics taught to engineers, but that the mathematics syllabi must be constructed and taught within an engineering context. However, it is clear that service mathematics is not an inferior form of mathematics. Howson, Kahane, Lauginie and de Turckheim (1987) emphasise the point, stating that the term *service mathematics* does not connote a lesser form of mathematics. They refer to it as "…mathematics in its entirety, as a living science, able - as history has ceaselessly show - to be utilised in, and to stimulate unforeseen applications in varied domains" (Howson et al., 1987, p. 1).

A qualitative study of service mathematics in Irish universities

The purpose of the study was to examine the context, the practice and experience of service mathematics teaching in Irish universities (Gill, 2006). No such study has ever been undertaken in Ireland. Consequently, the findings constitute a significant source of new data on service mathematics teaching in Ireland and serve as a basis for developing a meaningful characterisation of service mathematics in Irish universities today. The study aims to define more clearly the teaching/learning contract that exists between the actors in this sphere of activity using the concept of "Didactical Contract" as developed by Brousseau (Balachef. Cooper, & Sutherland, 1997).

In Brousseau's theory an implicit contract exists within every mathematics classroom between all actors in the sphere. Students are presented with mathematical tasks/problems by their teacher/lecturer. The students are required to work on the tasks whilst adhering to various constraints governed by the teacher/lecturer and the learning environment. The expected behaviours of the students from their teacher/lecturer and vice versa determine the didactical contract present in the classroom. Brousseau proposed that this contract has a significant impact on the teaching and learning that occurs in the class (Balachef et al., 1997).

Methodology

Qualitative non-participant observation was selected as the most appropriate strategy for data collection (Cohen, Manion & Morrison, 2000). This choice was influenced by the authors' need to gain an holistic insight into service mathematics teaching including mathematics lectures, tutorials and programmes in the world of Irish higher education. Brousseau's exhortation that an in-depth study of the routine happenings is the only way to establish the contract was also a major consideration. The study was guided by the following research questions:

- How is service mathematics perceived by lecturers and mathematics departments?
- How is service mathematics organised, planned and implemented?
- How is service mathematics taught?
- How is service mathematics assessed and evaluated?
- How do lecturers and students experience service mathematics?

Data collection instruments

The analysis presented is based on direct observations of classroom practice in each of Ireland's seven universities, and semi-structured interviews with experienced mathematics lecturers involved in service mathematics teaching. A purposive sample of lecturers, students and courses was used as explained below.

The method of inquiry was characterised by a multi-pronged approach involving both staff and students. Service mathematics lecturers from each of the seven Irish universities were approached in February, 2005 and asked to participate in the investigation. Selection was based on whether they taught first year service mathematics courses in the second half of the academic year. The lecturers (9) who replied and agreed to participate were the ones selected. The author first collected course documentation on each of the service mathematics courses in Irish universities to analyse their content. The selected lecturers were asked to:

- Complete a questionnaire (by e-mail);
- Participate in a semi-formal interview; and
- Allow structured observations of a *typical* mathematics lecture.

The participation of all lecturers extended the scope of study from University of Limerick experience (Science, Engineering and Technology) to all seven Irish universities and to include Arts, Commerce and Business Studies.

Once the initial lecturer-based investigation was complete, participating lecturers were approached for permission for the researchers to interview students on their courses and to observe some tutorial sessions. As some universities were approaching examinations/holidays at this stage of the process, this phase was conducted in only four of the original seven universities. Twelve (12) students in total volunteered to take part in interviews. The researcher also completed a journal of reflections after every lecture/tutorial observed.

All interviews were recorded and later transcribed for analysis. Data collected from interviews with lecturers and students, and from the lecture/tutorial observations were coded to distinguish between student-generated and lecturer-generated data. These data were subsequently analysed using the constant comparative method (Glasser & Strauss, 1967; Miles & Huberman, 1994).

Data analysis – the lecturers

Interview questions were based on current literature and authors' experiences in service mathematics courses and aimed to explicitly explore the behaviours lecturers may expect from their students. Such questions aimed to fully establish the didactical contracts within lectures. They were deemed essential by the authors in order to gain insight into what lecturers believed to be the nature of service mathematics e.g. mathematics for engineers, mathematics for scientists, applied mathematics or mathematics especially construed as service mathematics. For example, Howson et al. (1987, p. 1) suggest that the term s*ervice mathematics* refers to "mathematics in its entirety*"*. Consequently, it should be possible to devise an apt, authentic curriculum for these students (Kent & Noss, 2001). It is crucial to examine how seriously service mathematics is treated within mathematics departments and client departments, how it is planned, implemented, assessed and evaluated.

Data analysis – the students

The 12 student interviewees (5 male, 7 female) were all first year university students of approximately 18 years of age. Mature or foreign students were not considered, as issues of transition from Irish second level were the principle research questions. However, issues that arise out of this analysis will impact significantly on adult learners. The student interviewees were enrolled in various degree courses which had a mathematics element such as Science, Commerce and Business Studies. Two students were studying an Arts degree and had elected mathematics as one of their first year subjects. Some of the students were interviewed individually, while others were interviewed in pairs or threes. Each interview took place at the end of the lecture/tutorial and lasted about 10 minutes. The potential bias was that the students interviewed were the ones who actually attend their tutorials. It was not possible to interview students who did not attend class.

Summary of findings

One of the findings from the qualitative study is that service mathematics is viewed as a very important enterprise within Irish universities for financial/staffing, political and educational reasons. Five of the universities have coordinators to facilitate the preparation and delivery of service mathematics courses. It is a significant role to be filled as they have a number of important duties to fulfil.

The lecturers interviewed stated that all students should have a good mathematics education and it is their job to provide it. It was disheartening to see that over half of the lecturers interviewed still viewed the teaching of mathematics students as a higher priority than service mathematics students.

The lecturers indicated that they perceive service mathematics as mathematics for students not doing mathematics degrees. This marginally negative perception is interesting because it shows that lecturers understand that students see service mathematics as something that is not chosen for its own sake as a path to some career. Superficial definitions were given to explain how the lecturers characterise service mathematics.

Mathematics lecturers prepare service mathematics syllabuses in conjunction with the client departments. The client departments decide what they would like their students to know and the mathematics departments tailor courses to suit their requirements. Apart from the client departments (and the external examiners) there is no external input into course design. Industry and prospective employers are a potential source of input but are not exploited. This runs contrary to accepted practice espoused by earlier researchers such as Bajpai (1985) who advocated industry involvement in course design. The aims and objectives for the service mathematics courses are outlined in the course documentation. They infer that service mathematics courses are technique/application based as opposed to theory-based courses. The level of rigour is not, rightly or wrongly, as deep as that in mathematics specialist courses. The lecturers interviewed stated that the *general gist* would do for their service mathematics students and they do not attempt to get them to really grapple with the concepts involved. This is worrying in the context of what other researchers (e.g. Howson et al., 1987) have to say about service mathematics as not being inferior mathematics. However, Mason (2001) cautions against an overly theoretical approach.

The students in these courses are required to have attained a pass (C3 for some, B3 for others) in Ordinary Level Leaving Certificate mathematics (Irish School Leaving Certificate is offered at 3 levels in mathematics: Higher, Ordinary and Foundation) to gain entry to these courses with the exception of the Engineering degree courses who require a grade C3 or higher at Higher Level Leaving Certificate mathematics. As these are the minimum entry requirements, the mathematical abilities/knowledge of students vary to a great extent, as many groups will have students with anything from an Ordinary Level C3 up to a Higher Level A1. In addition, there are transferees, foreign students and mature students. Many of the latter have not studied mathematics for many years and some have not even sat the Leaving Certificate examination at all. Class size and the diverse mathematical backgrounds of students negatively impact the lecturers and students. The smallest service mathematics group observed/surveyed had 50 students enrolled. The rest contained between 100 to 400 students. The lecturers interviewed admitted that it was more difficult to get to know students and monitor their progress as a result of the class sizes. It inhibited their teaching and led to chalk and talk styles of lecturing. They seemed despondent about this situation but accepting of it. There was a distinct lack of

interaction, group work and discussion within these lectures as lecturers felt it was not feasible and students feel too intimidated to do anything other than passively participate.

The use of relevant, real-life examples was something that was absent from the lectures observed. It would not be possible for an observer to tell if some of the classes were for engineers or scientists unless they were informed so. Time constraints were partially blamed for this while some lecturers said it was very difficult to always give relevant examples from everyday life. As a result, students *participate* in mathematics lectures which they have not chosen to study without being given clear reasons why. The use of appropriate examples from science, engineering and technology is strongly advocated by IMA (1999), Kelly (1994) and Ahmad, Appleby and Edwards (2001).

Observations revealed that students passively participate by listening and taking notes. There were very few opportunities for group work or discussion with the result that there was very little interaction within lectures. Class size was the main reason given for lack of interaction and questioning. Lecturers do not like to intimidate students and students are too shy to speak up in class even if they do not understand something. Very little questioning took place in the lectures observed. The students admitted that they would not ask questions in class. Lecturers rarely asked questions either. A few questions were "tossed out" by lecturers at the groups observed. There were no individual questions. The students interviewed for this study indicated that their attitudes to mathematics were once positive but are now neutral and, at times, negative. This implies that mathematics has been an unsatisfactory experience for them thus far in higher education.

Tutorials were taught by teaching assistants/tutors or, sometimes, by fourth year students. The lecturers stated that tutorial/homework materials were a combination of technique-based and applied problems based on material covered within the lectures. It was left at the assistants' discretion how best to teach the tutorials. Lecturers tried to make examples as relevant as possible to core areas but often found this difficult. Tutorials were seen as an opportunity to practice skills taught within lectures. They were also seen by students as an opportunity to pick up on material they had missed/misunderstood/not understood within lectures. They felt more comfortable approaching tutors than lecturers. The students admitted that they did not do enough independent study outside of lectures and tutorials. Attending tutorials offered students the chance to practice the mathematics they may or may not have the confidence or knowledge to attempt on their own.

Assessment varied from university to university. Students were assessed by either continuous assessment methods or one final end of term/year examination. The lecturers interviewed said that they were somewhat focused on the final examination but they did not go out of their way to teach to it. Still, some of these groups have final examinations that worth 100% of the assessment mark so this, in addition to their second level experience and its emphasis on the Leaving Certificate examination (Murphy, 2002), leads students to focus more on passing the examination than on understanding the mathematics. The students interviewed stated that they relied on previous examination papers to prepare for their next examination. It was possibly the shortest route to getting through the examination as none stated that they referred to textbooks, online support or drop-in centres as an aid to their learning.

It was evident that there was a clear mismatch in expectations and delivery within these classrooms and one that could contribute further to the problems within service mathematics teaching and learning. Lecturers expected students to attend, listen, behave and think. They also

expected them to take responsibility for their own learning. Students had great difficulty taking this responsibility on board. The transition to third level education was seemingly a substantial hurdle for students as attendance and participation rates were poor. It is the students' responsibility to attend lectures and tutorials, but it may be more than laziness or indifference that stops them from going. They seemed to expect certain things from their lecturer e.g. extra office hours, but then do not take advantage of them. The lecturers said that they do not expect very much of their students as regards classroom etiquette and participation.

Discussion of findings

Observations on the nature of the didactical contract in service mathematics in Irish universities

As stated, one of the purposes of this study was to determine the nature of the didactical contract within service mathematics classes in Irish universities: to see if, where and why there are mismatches in expectations. It is clear that there are many such mismatches evident in the data from within these groups.

Lecturers expect students to attend lectures and tutorials yet, attendance is a problem in these universities. While in class the students are expected to behave, listen and think. Questions are welcomed from students but not expected or encouraged because of large numbers within the service mathematics groups. Lecturers do not ask individual questions but on occasion they do ask some questions to the group as a whole. Students are compliant with this. Thus large classes are taught in traditional ways where student attitudes towards their task are less then ideal. This finding echoes Simons (1987) and more recent work by Crawford, Gordon, Nicholas, and Prosser (1994) and MacBean (2004). However, students feel more comfortable asking questions in tutorials and sorting out their problems there. This is the one area where students and lecturers have the same expectations of each other. Students expect not to be asked questions and lecturers do not ask them. Some form of intervention is needed to encourage attendance and participation rather than just accepting that this is the way it is. Maybe if expectations were more obvious at the start of the academic year, everyone would be enlightened as to their own contribution to the service mathematics experience.

There are few opportunities for students to practice their mathematics within lectures because of time constraints and because the lecturers expect students to do some independent work of their own outside of class. Students, however, expect time, opportunities and plenty of examples to practice. They expect the lecturer to explain everything in detail, as practiced inn secondary school. Having spent 5 years experiencing teaching of this form, it is difficult to make the change to the lecturing style of teaching. Students are not satisfied if they are left to work alone. A mismatch in expectations is evident. The students expect more than the lecturers provide. They expect everything explained in detail something the lecturers do not do. The lecturers expect students to fill in the gaps for themselves but the students believe this the lecturers' role. This mismatch causes frustration for the students who feel they are being short-changed. If the lecturers' expectations were made clear at the start of the term, it is possible students would not have this added frustration. They would know that the onus is on them to do some work themselves. Lecturers expect students to take more responsibility for their own learning i.e. to become more self-directed in their approach.

Tutorial sheets and homework are given to students on a weekly or fortnightly basis. The lecturers expect students to spend one-hour of independent study per one-hour lecture on their lecture material and their homework. The students admit that they do not spend this much time on their mathematics study. The lecturers expect students to attempt their homework but students do not attempt it unless it is part of their final mark. They do, however, attempt the work within tutorials under the guidance of their tutor/teaching assistant. Teaching assistants decide how they teach the tutorials and should report back to the lecturer if there is a problem. Again, there is a mismatch in expectations. Students do not put in the effort lecturers' expect so this causes some annoyance for all parties. It seems that Irish students have resolved the issues in some of the more important debates around service mathematics teaching in favour of 'lesser mathematics' e.g. skills rather than concepts (Bajpai, 1985), and tools rather than understanding.

Students are expected to revise for examinations themselves. It is not the lecturers' responsibility to revise examination papers in class. The students do expect the lecturers to revise past examination papers in class, inform them of the layout of the paper and the order of questions on the paper. They also feel that the lecturer should revise material taught months beforehand. They have not revised material from the previous term themselves and feel the lecturer should help them out more.

Students expect their lecturers to make themselves more available to students and be approachable. They should put on extra office hours around examination time for any queries they might have regarding their lecture notes or examinations. The lecturers do inform students that they already have this opportunity but few students take advantage of the offer.

In summary the principle features of the didactical contract that operates within the Irish service mathematics contexts surveyed in this study are:

- Lecturers expect that students will attend lectures and tutorials;
- Lecturers do not ask or expect questions in large lectures nor do students expect or ask questions in large lectures;
- Students are expected to come prepared to tutorials and participate fully;
- Lecturers expect students to prepare for examinations themselves;
- Students are expected to do independent study including filling gaps in concept development, practicing skills and procedures, preparing for tutorials and completing assignments;
- Students expect the lecturers to explain everything in detail in lectures and to provide time, opportunities and examples to practice;
- Students expect lecturers to revise past examination papers in class, discussing the layout of the paper and the order of questions; and
- Students expect their lecturers to be available and approachable to discuss queries regarding their lecture notes and examinations.

When a mismatch in expectations occurs, one or all parties are going to feel hard done by and frustrated. Motivation levels are likely to drop as a result and negative feelings are likely to increase. By the end of the academic year these frustrations may snowball and add disappointment, irritation and resentment to an already problematic area. This is particularly pertinent for adults trying to learn mathematics. Many have not studied advanced mathematics for many years, if ever, and so from the outset have added fears and frustrations that students entering directly from second level do not often possess.

Preliminary characterisation of service mathematics

The authors contend that the nature of service mathematics has never been fully defined or truly understood by service mathematics practitioners because it is under-theorised. This lack of understanding may exacerbate an already difficult situation in a vulnerable arena where student mathematical proficiency is not as high as it once was or is not strong as in non-traditional groups e.g. adult learners. The following is a characterisation of service mathematics as practiced in Irish universities today. This profile emanated from direct observation of classroom practice in all seven Irish universities, in addition to analysis of questionnaires, course documentation and semi-formal interviews with lecturers and students on service mathematics courses.

Service mathematics is distributed across many disciplines and faculties and is identified in various ways such as engineering mathematics, mathematics for engineers and scientists, mathematics for computing, mathematics for business, technology mathematics. The following statements capture the meanings associated with the concept *service mathematics* in the study:

- Service mathematics is directed at client groups composed of non-specialist users of mathematics;
- Service mathematics is technique/application based as opposed to theory based;
- Mathematics content is negotiated between mathematics and client departments with no external input from industry or employers;
- Courses are usually offered in the traditional large lecture/tutorial format;
- There is a large diversity in mathematical background and attainment of learners;
- Lecture style is usually "talk and chalk" supported with limited resources e.g. white/ blackboard, overhead projector;
- There is very little interaction or questioning in lectures;
- The use of real-life mathematical examples is acknowledged as being important but is invariably absent;
- Assessment varies between end-of-term examination and end-of-term examination combined with some form of coursework or continuous assessment;
- Additional learning support may be available and comes in a variety of formats including drop-in centres, support tutorials and other learning centre activities; and
- It is common for class notes to be supplied in book form supported by appropriate textbooks for non-specialists.

The authors adapted research tools and frameworks from education to advance our knowledge and understanding of service mathematics and the practice of service mathematics in Irish universities. These include Brousseau's didactical contract (Balachef et al., 1997). While mature adult learners were not involved directly in the study, emphasis in this case is the service teaching/learning environment as a place where a significant and growing number of adults are involved, hence the focus on the didactical contract and a characterisation of the whole environment in a different way.

Results of this study uncover a narrow didactical contract from which lecturers and students rarely deviate. It is worth noting in this context that the analytical tool used, viz., the didactical contract, was developed from studies of school classrooms and that university conditions differ significantly in a number of respects that affect the contract. University conditions for service mathematics teaching involve very large class sizes and an implicit multi-partite agreement distributed over several actors including students, lecturer and tutorial assistant(s). This and other aspects of the *university learning contract* merits further research attention. Class size

inhibits teaching styles and, therefore, students' mathematical progress. This poses many problems for mature students who start university after an absence from study and with lower mathematical proficiency and then are faced with less than satisfactory learning environments.

One of the authors, Gill, has taken this analysis forward in her doctoral thesis (Gill, 2006) and developed a theoretical model of service mathematics as a pedagogic discourse within the discipline of mathematics following Bernstein's (1996) work on curriculum.

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