Most commonly occurring mathematical difficulties - eight weeks in the life of a Maths Support Centre

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Abstract

The Maths Support Centre (MSC) in University College Dublin (UCD) was established in 2004 and has seen an annual increase in the number of visits to the centre, with just over 5,600 visits for 2015-2016. For each visit, there is an electronic record of the module for which the student is seeking support, along with details, inputted by the MSC tutor and available to the module lecturer, on the exact nature of the mathematical difficulty experienced by the student.

In Semester 1 2014 we undertook an eight week qualitative study of the mathematical topics, for which students attending the MSC, sought support. We focused on identifying and recording the areas of mathematical difficulty which students encountered while working through problems in the centre. There are approximately 2000 entries on our database over this period.

In this paper we present our findings. We describe the most commonly occurring areas of mathematical difficulty experienced by those who visited the MSC during the eight weeks of the study, and highlight those areas for which students from across a number of modules sought support. Some examples used demonstrate where even students from higher level modules struggled with basic mathematical concepts.

We briefly address what possible forms of support that may be provided for students as a result of this study.

1. Mathematical Transition to Higher Education

Serious concerns have been expressed in relation to the mathematical preparedness of entrants to Third-level courses in mathematics, science and engineering in the UK (The Royal Society, 2006). Similar to the UK, issues concerning the level of mathematical skills of new entrants to HEIs in Ireland are noted (O'Donoghue, 2002). Diagnostic testing as carried out in many higher level institutes is effective in highlighting widespread areas of mathematical weakness (Lawson et al., 2003).

A major response in both the UK and Ireland to the Mathematics Problem has been the introduction of mathematical and statistical support centres. These centres were most frequently introduced to provide mathematical support to students in the transition from post-primary to higher education. Mathematics Support, is described by Lawson et al. (2003) as "a facility offered to students (not necessarily of mathematics) which is in addition to their regular programme of teaching, lectures, tutorials, seminars, problem classes, personal tutorials, etc." (p.9). The authors also note that support offered by MSCs can vary significantly but almost universal aspects are the voluntary nature of attendance and the one-on-one support offered either by drop-in or by appointment.

Kyle (Marr and Grove, 2010), remembering his description of the early mathematics support as "a form of cottage industry practiced by a few well-meaning, possibly eccentric individuals" (p.103), notes that MSCs now play a respected and widely expanded role in higher education. The increase in the number of MSCs is substantial, especially over the last fifteen years. Independent surveys demonstrate this growth (Lawson et al., 2001, Perkin and Croft, 2004, Perkin et al., 2013, Gill et al., 2008, Cronin et al., 2015). See Table 1 below.

Table 1 Number of MSCs in UK and Ireland

Date of report	UK			Ireland	
	2000	2004	2012	2007	2014
Number of MSCs	46	66	88	13	26

Lawson (Marr and Grove, 2010) reminds us that "the most fundamental issue that must be addressed regarding mathematics support is funding" (p.16). Possible improvements to the efficient running of a centre are an important consideration in this respect.

2. What data should a Maths Support Centre collect?

In September 2013, we embarked on a research project in UCD Maths Support Centre to develop a process of qualitative data collection. We believe that the information gathered by the UCD MSC, particularly the comments entered by the tutors on students' difficulties, is a very valuable resource not alone for the centre but also for the module lecturer.

Given that student demand for mathematics support is increasing and funding is limited, a fundamental issue that must be addressed is how to maintain the high level of quality teaching and at the same time increase the service in a cost effective manner.

This research focuses on identifying and recording areas of mathematical difficulty which students encounter while working in the centre and on analysing the data to address the following research questions:

i. What if any are the common mathematical difficulties which students present at the Maths Support Centre with from across modules?
ii. Does this level of detailed data collection contribute to the efficiency of a centre by aiding development of effective supports for students?
iii. What level of feedback, if any, would lecturers like to receive on their students' visits to an MSC?

In this paper we will address the identification and categorization of the mathematical difficulties and discuss the development of effective supports. A discussion of the third research question is beyond the scope of this paper.

3. Methodology

3.1. Collection of data

In order to identify the mathematical topics with which students experience difficulty firstly, we needed to determine the nature of the data we required to do this rigorously and secondly, to work with the tutors to find ways in which they could classify this data and record it efficiently. Data collection for our pilot study commenced in February 2014. For eight weeks the first author cross-checked the tutor entries on the database with the entries in the A4 carbon copy notebooks used by the tutors while working with students in the MSC. Tutors were asked for more information if the basic problem was not clearly identified. In September 2014, we commenced our data collection. This involved eight weeks of intensive collaborative work with the tutors to ensure the quality and authenticity of the data collected and resulted in entries recorded, and coded by mathematical area, for over 2,000 student visits. Further details of this collection process are available in Curley and Meehan (2015a).

3.2. Analysis of data

The first step in the analysis involved the first author reviewing the codes assigned by the tutors to each topic entry. Following this the second author and Dr Anthony Cronin, manager of the MSC, verified the coding process undertaken by the first author.

On examining the entries under each code, the difficulty in deciding if a topic entry represented a basic mathematical difficulty, in the absence of knowing the module from which problem arose, became apparent. We therefore altered the focus of our analysis from individual entries to entries by module. Further details of the analysis can be found in (Curley and Meehan, 2015b).

4. Results

For this paper we focus on 17 large modules varying in size from 61 to 522 students. Over the eight weeks of data collection, the MSC had a total of 981 visits from students enrolled to these modules, with 191 of these visits having no entries submitted to the database. In our analysis, we identified a total of 1,400 mathematical difficulties in the remaining 790 entries. Our findings are summarised in Table 2 below.

A row in Table 2 represents the areas of mathematical difficulty identified in the particular module. A column displays the topic or category of mathematical difficulty. Students from each of the seventeen modules examined experienced difficulty in at least one of the topics listed.

The major topics of difficulty for students were numeracy and algebra. Students from eleven modules out of a total of seventeen examined, experienced problems here.

Table 2 Mathematical difficulties experienced by MSC students in 17 modules.

Mathematical Difficulties	Numeracy	Algebra	Indices & Logs	Trigonometry	Graphs & Functions	Differentiation	Statistical tables
Modules							
Introductory Maths	*	*	*			*	
Discrete Maths	*	*			*		
Calculus A	*	*		*	*	*	
Calculus B		*	*	*	*		
Calculus C	*	*	*		*	*	
Calculus D	*	*	*	*	*	*	
Linear Algebra A	*			*			
Linear Algebra B	*	*	*	*			
Number theory A	*	*	*				
Number theory B	*	*	*				
Applied Maths A		*	*		*	*	
Applied Maths B	*	*	*	*			
Applied Maths C				*	*		
Physics				*	*		
Statistics A	*						*
Statistics B							*
Statistics C							*
Total difficulties	11	11	9	8	8	5	3

Keeping in mind, that we are also analysing the data with a view to answering the question does this level of detailed data collection improve the efficiency of a mathematics support centre by aiding development of effective supports for students, we need to find areas of mathematical difficulty present across modules and capable of explanation in a short video or online resource? Disappointingly our analysis of the data provides only one suitable category of difficulty. This we find common across the three statistic modules. In this case development of suitable support in the use of normal

distribution tables may potentially contribute to improvement in the efficient management of the centre.

5. Discussion of results

Overall, the absence of similar mathematical difficulties common to a number of modules is surprising given the number and detail of entries. One possible explanation for this may indeed be the high level of detail reported. The broad range and varying level of mathematical difficulty for which students sought support and the skilful uncovering and reporting of specific issues by the tutors gives a very detailed knowledge of a difficulty that might otherwise be classified in general terms.

To explain this reasoning further we give some examples of the specificity of algebraic mathematical difficulties expressed in tutors' comments.

> *When doing following question the classic cancellation problem occurred of cancelling across addition as below;*
> *a/(b+c) + b/(a+c) + c /(a+b)=(a(a+c)(a+b) + b(b+c)(a+b) + c(b+c)(a+c)) / (b+c)(a+c)(b+a). (Student) wanted to cancel (a+c) underneath with (a+c) in first part on top. Tutor showed example of when you can cancel and when you can't cancel: (3x+5)/x and 3(x)(y)/3. (Introductory Maths)*
>
> *Student also had a problem with solving quadratic ax^2+bx=0. They asked but there is no number? This problem would be a more common problem with students whose algebra is weak. (Calculus C)*
>
> *Actual problem was with the algebra at the end to make the two sides look the same: LHS n(n+1)(2n+1)/6 + (n+1)^2; RHS (n + 1)(n + 2)(2n +3)/6. (Number Theory B)*
>
> *How to find the fixed points of u^2 +u(1-A) = 0. Student was confused I think by how complicated it looked, once I pointed out that in ax^2+bx=0, there was no c, students realised that they could take out the u. (Applied Maths)*

Where two entries, as shown above, need mathematical knowledge to solve a quadratic equation perhaps a tutor, entering less detail might have entered "problem with quadratic equations". But the level of detail entered has shown the knowledge required in both cases is quite different. We suggest that a basic video demonstrating the solution of quadratic equations, suitable for the less detailed entry suggested, would not provide for either of these students the level of support required.

The reason perhaps, that many tutor comments have recorded the reading of statistical tables as a problem is they believe that just as solving a quadratic by using the formula may simply be the application of a specific method so also methods can be devised for reading tables without necessarily a full understanding of the outcome.

6. Conclusions and further research

To answer the second question as to whether this level of detailed data collection improves the efficiency of a centre by aiding development of effective supports for students, the analysis of the data would indicate if the sole purpose is to increase the efficiency of a centre, and keeping in mind the loss of tutoring time it may not be an efficient process to do so.

But our question of what data should a centre collect has not been fully explored.

What level of feedback, if any, would lecturers like to receive on their students' visits to an MSC? As mentioned earlier our tutor entries are available to the module lecturer in

our school and we are currently analysing interviews with lecturers in an attempt to address this question.

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