The challenge of collecting useful qualitative data on students' visits to a Mathematics Support Centre at a university in Ireland

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Since September 2009, the Mathematics Support Centre (MSC) in University College Dublin (UCD) has kept an electronic record of each student visit to the Centre. By September 2013 there had been 21,200 visits and an analysis of the qualitative data, specifically the tutors' comments on students' difficulties, was planned to identify the mathematical topics and concepts that were causing persistent difficulties. However we found the nature of the data collected lacked the detail to allow the analysis to take place. We realized that in order to identify the mathematical topics with which students experience difficulty, firstly we needed to identify the nature of the data we required and to do this rigorously and secondly, to work with the tutors to find ways in which they could identify this data and record it efficiently. We describe our efforts, and those of the tutors, over the last eighteen months to collect this data. In September 2014, we commenced our data recording proper. This involved eight weeks of intensive collaborative work with the tutors to ensure the quality and authenticity of the data collected. During this period there were 2,012 visits to the MSC. We also present a preliminary analysis of the most prevalent mathematical topics that are emerging from this eight-week data collection.

Keywords: mathematics support centre; basic mathematical problem areas; data collection; collaborative work with tutors; evidence based approach.

Introduction and background

For the past twenty-five years lecturers, teachers, educational policy makers and researchers have struggled to find explanations and solutions for what has become known as the "Mathematics Problem". Although mathematics support originated with the work of Ian Beveridge (Beveridge, 1994) it mainly came into prominence in the period 2000-2010. The influential report "Measuring the Mathematics Problem" (Hawkes & Savage, May 1999, iv) identified major issues facing mathematics and engineering departments in higher education institutions in the United Kingdom (UK). This report made a number of recommendations, amongst which was that "prompt and effective support should be available to students whose mathematical background is found wanting". The provision of mathematics support was viewed by many as a means of addressing this issue. Similar concerns with the number of students entering third level education in Ireland without basic mathematical skills had been reported by Hourigan and O'Donoghue (2006) and Lyons, M., Lynch, K., Close, S., Sheeran, E., and Boland, P. (2003) amongst others. The first mathematics support centre in Ireland was established in Limerick University (UL) in 2001, with UCD and Dublin City University (DCU) opening their mathematics support centres in

2004. Currently, almost all third level colleges in Ireland offer some form of mathematics and statistics support to their students.

The Mathematics Support Centre in UCD

UCD is the largest university in Ireland with over 26,000 students. The nature of the mathematics support service in UCD was originally envisaged as supporting students who were struggling with mathematics in the transition from post-primary to third-level education. The range of support provided grew over time to the point where now, the Mathematics Support Centre (MSC) is embedded as a university-wide resource. Visitors to the MSC may be students studying a mathematics degree programme, or may be taking mathematics modules as part of another programme of study for example, Agriculture, Business, Engineering or Science. Indeed students who are not studying any mathematics module but need some knowledge of mathematics for their programme also attend the Centre. These might be students from degree programmes in Geography, Psychology, Medicine or Social Science programme. The number of visits to the MSC increased from 700 in 2004 to over 6,000 visits in 2013-2014. Also in this academic year, there were visits from students from 315 different modules across UCD, with 48% visits from first year students, 26% from second years, 15% from third years.

Traditional Data Recording in Mathematics Support Centres

The importance of collecting and maintaining accurate records of students' visits to support centres has been emphasized in much of the literature. In the early days of mathematics support, usage statistics were employed mainly as a reason to maintain or increase funding. For example Croft (2000) recommended that usage statistics ought to be kept to make the case for future funding. Another study (Lawson, Croft, & Halpin, 2003) advocated the counting of return visits as a method of measuring effectiveness of a centre while a further study looked at retention rates of at-risk students comparing the results of those who attended the centre with those who had not (Dowling & Nolan, 2006).

The MSC in UCD also recognised the importance of presenting an evidence-based rationale to university management for funding of the Centre. In 2009 an electronic database system was set up. On this database we recorded information on each student visit - the length of visit, the degree programme the student was enrolled on, the module for which he or she was seeking assistance, and other background data. We also recorded information on the issues for which the student sought support. This information was entered on the database by the MSC tutors after each student visit. Our study mainly concerns these tutor entries and we will refer to them in this paper as 'topic entries'. Records of approximately 25,000 student visits have been maintained on our database since September 2009. The system is designed to enable lecturers in the School of Mathematical Sciences to access 'topic entries' for their modules, as soon as the tutor enters the information on the database. The student name or number is not available to the lecturer. Since January 2015 this log-in process has been significantly improved.

The Aims of our Research

> We aim to identify university students' mathematical 'trouble-spots' and develop effective supports.

Diagnostic testing, as carried out in many third-level institutions, has been effective in identifying and highlighting widespread areas of mathematical weakness. A cursory glance at the MSC 'topic entries' suggested that there were certain basic mathematical issues and concepts that caused persistent difficulties for students. We believed that this information gathered by the MSC, particularly the comments entered by the tutors on students' difficulties, was a very valuable resource. However our initial look at the data in October 2013 proved disappointing. We found the tutors' comments on the 'topic entries' too broad in nature and lacking in the detail. The following are some examples:

- Trigonometry, Vectors
- Changing units, Scientific notation
- Limits

In addition there was no efficient method for extracting entries on a particular mathematical 'trouble-spot' from the database. For example if we wanted to examine all entries relating to indices, we had no efficient way to do so,

Data Collection - A Pilot Study

Our challenge was to develop a process of qualitative data collection. We needed to find a way to gather more meaningful data, while bearing in mind that this had to be recorded by tutors working in a very busy MSC. In January 2014 the first author initially coded thirteen areas that she knew from experience of working in the MSC, caused problems for students. These are the initial codes.

Basic algebra$\{a\}$	Factorising$\{f\}$	Inequalities$\{in\}$
Converting units$\{cu\}$	Probability$\{p\}$	Statistics$\{s\}$
Rules of signs$\{s\}$	Logarithms$\{l\}$	Unit vector$\{uv\}$
Trigonometry$\{t\}$	Indices$\{i\}$	Sim. equations$\{se\}$

We held a focus group in mid-January 2014 with eight experienced MSC tutors. We informed them of our pilot study, presented them with the list of codes, and asked for suggestions on how to improve our data collection efficiently. At this focus group the importance of identifying the basic problem experienced by the student was emphasised. To illustrate the quality and nature of the tutor entry we aimed to collect we presented and discussed the following examples:

1. One student did not know

$$\frac{x}{2} = \frac{1}{2}x \qquad \{a\}$$

2. Another student believed

$$\frac{x}{2} = x^{-2} \qquad \{a\} \quad \{i\}$$

3. A student asked why $\sin x$, $\cos x$, $\tan x$ changed sign as x goes from 0 to 2π

$\{t\}$

These are examples of basic problem entries and each entry has been assigned at least one code. We also used the following two examples to describe the difference between a valuable and a less valuable 'topic entry':

Example A:
A Student had a problem with limits and continuity and also a problem factoring out the "h" and expanding in a question on first principles. {a} {s} {g}

Example B:
A Problem simplifying an expression (common denominator.)

$$P = 220 - n\left(\frac{200}{n+1}\right) \qquad \{a\} \qquad \{i\}$$

It is unclear in Example A what the student difficulty is. Was it a question of expanding the square or cubic brackets? What was the problem with limits and continuity? In example B the student's difficulty is stated much more clearly. The student was unable to simplify the expression using a common denominator.

As a result of this meeting the tutors made some excellent suggestions. Firstly, we added extra codes:

Co-ordinate geometry{*cog*}	Critical points{*cp*}	Pattern spotting{*p*}
Mathematical expressions{*me*}	Differentiation{*d*}	Integration{*d*}
Graphs{*g*}	Functions{*f*}	Vectors{*v*}

Secondly, we decided that in many cases it would be beneficial for the tutor to enter the equation or problem in the database. They could do this using Latex. Finally, their most innovative suggestion was the use of A4 notebooks with carbon copy sheets. At the end of each visit, the student would be given the top sheet and the copy was retained in the MSC. This allowed the first author to match each 'topic entry' entered in the database with the actual work covered by the tutor with the student.

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. Tutors were asked for more information if the basic problem was not clearly identified. Below are some examples of the data collected during the pilot study:

1. Student was finding the critical points of ln(cos(x)) but did not know that if $\frac{a}{b} = 0$ then a must be zero and b not zero. $\{a\}, \{fr\}, \{cp\}$
2. How to find a condition that ensures that a 2 x 2 matrix has two equal eigen values. Student needed to know that $b^2 - 4ac = 0$. $\{a\}, \{m\}$.
3. Solving an indefinite integral but student needed basic algebra, to simplify $e^{sin(x)+c} = e^{sin(x)}.e^c$ $\{a\}, \{int\}$

Data Collection – The Research Study

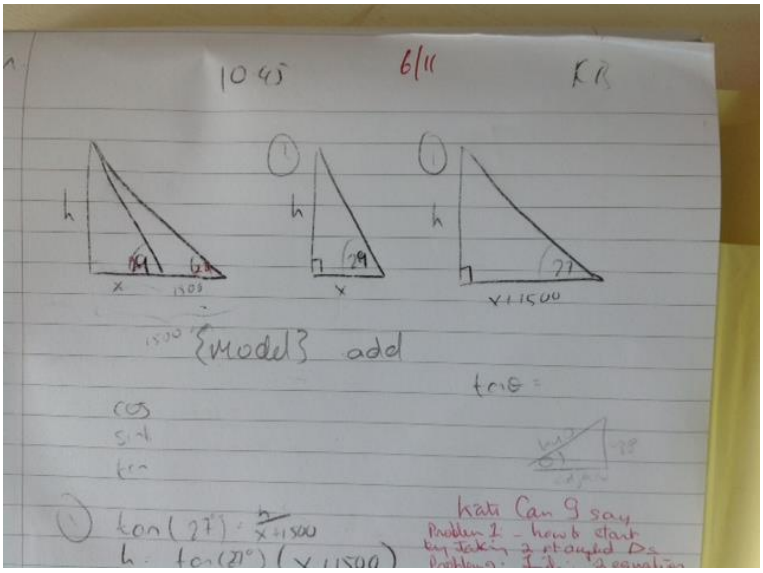
The authors conducted a second focus group with the MSC tutors in September 2014. The tutors were positive about the method of data collection used during the pilot study. However they suggested making the codes more explicit, and therefore easier to remember.

The first author cross-checked the 'topic entries' on the database with the A4 entries in each tutor's carbon copy workbook on a daily basis. On average there were 50 entries to be checked each evening. To demonstrate this method of validation of 'topic entries' we show an example of one database entry and the corresponding entry in the tutor notebook. Firstly we present the database entry:

> Surveyors are looking at a clifftop. They look up at an angle of 24 degrees and move 1500m closer and are at 29 degrees to the top. Find the height?
>
> Used method of calling the unknown length x and dividing into two triangles and making two sim equations and solving for x and height. {trig},{frac},{fact},{alg}

The tutor has entered the question and described the method of explanation used.

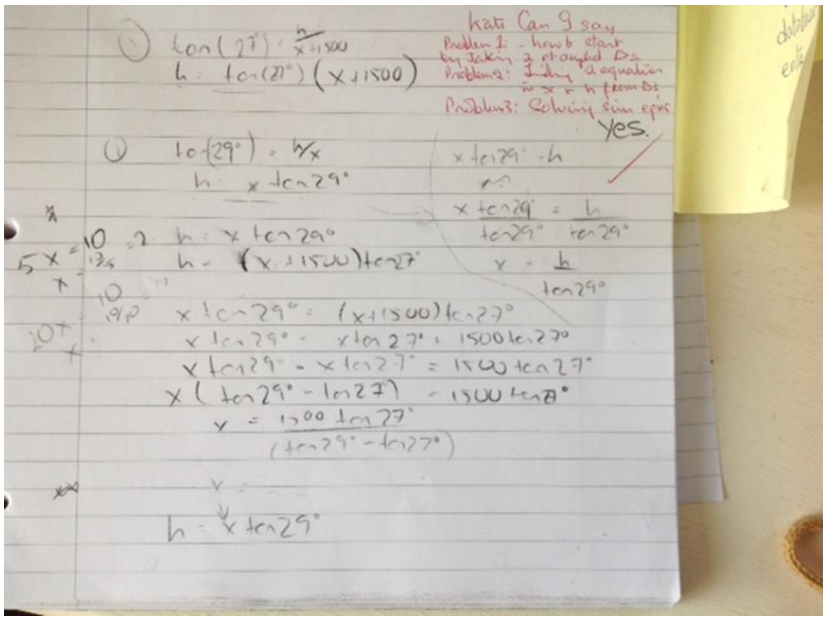
The approach to the solution was to split the diagram into two right-angled triangles and find the height. Here is the entry from the tutor notebook.



At the top of the page you will note a time, a date, and the initials of the tutor. The student's first name is concealed on the left. This allows us to match the page with the 'topic entry'. On the lower right-hand side you will see a query to the tutor asking for further explanation. The query asked if the following were the 'trouble-spots' for the student.

> How to start by taking two right angles? Finding two equations in *x* and h from the triangles? Solving simultaneous equations?

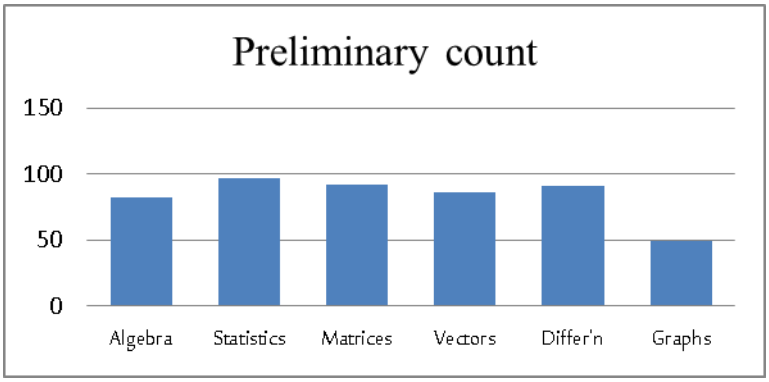
On the lower half of the same page (see below) you will see the tutor has agreed.



Also you will see, on the left hand side of this page, the tutor's explanation of an approach to take when solving an equation by showing the following
'$5x = 10, x = 10/5$.' All the extra information gathered was added to the database.

Analysis of Data

In January 2015 we began a preliminary analysis of our data. There were 2,012 entries over the eight weeks. Some of the students sought help for more advanced topics, coded as {adv} and these were removed from the analysis. A small number of students attended the MSC to study but not seek help. These visits were also removed leaving a total of 1,500 'topic entries'. Each of these has at least one code.



Above is the number of entries under the six major codes. The analysis is still at a very early stage but the research so far is showing some interesting results, which we hope to expand on in a further paper.

References

Beveridge, I. (1994). *Maths Support Survey – an Examination of Maths Support in Further and Higher Education*. Maths Support Association Newsletter – Issue 1 – Spring 1994 p13. *Archived on the sigma website*(Issue 1 - Spring 1994), p.13.

Croft, A. C. (2000). A guide to the establishment of a successful mathematics learning support centre. *International Journal of Mathematical Education in Science & Technology*, *31*(3), 431-446. doi: 10.1080/002073900287192

Dowling, D., & Nolan, B. (2006). *Measuring the effectiveness of a maths learning support centre-The Dublin City University experience.* Paper presented at the CETL-MSOR Conference 2006.

Hawkes, T., & Savage, M. (May 1999). Measuring the Mathematics Problem: The Engineering Council.

Hourigan, M., & O'Donoghue, J. (2006). Moving Closer to Solving the'Mathematics Problem'Where it Arises: The Influence of the'Typical'Irish Pre-tertiary Mathematics Experience on Under-preparedness among Numerate Entrants.

Lawson, D., Croft, A., & Halpin, M. (2003). Good practice in the provision of mathematics support centres. *LTSN Maths, Stats & OR Network*.

Lyons, M., Lynch, K., Close, S., Sheeran, E., & Boland, P. (2003). Inside Classrooms: a Study of Teaching and Learning. *Dublin: Institute of Public Administration*.