Making Maths More Meaningful: Successful Support Structures for Struggling Students

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Abstract: Dublin Institute of Technology (DIT) Students' Maths Learning Centre (SMLC) is a new initiative that aims to provide mathematical support in a relaxed, non-judgemental environment to any DIT student whose programme contains a mathematical element. DIT is a multi-level institute, with over 21,000 students registered on more than 400 programmes at apprenticeship, certificate, diploma, degree and postgraduate level. The range of mathematics studied within these programmes is vast and many students find that they need additional support in this area. However, because the institute is split into numerous campuses, it has proved necessary to develop a two-fold approach, incorporating one-to-one tuition, through the form of drop-in sessions, alongside an extensive e-learning support system, so as to provide the optimum learning environment. We explore the challenges of developing this system for such a diverse student population and take a detailed look at the most common mathematical difficulties encountered by students using the service. We also consider the effectiveness of the e-learning approach when contrasted with more traditional face-to-face learning techniques and highlight the type of students who are likely to reap the most benefit from each approach.

1. Introduction

In 2002, a study (Costello and Russell, 2002) was conducted within Dublin Institute of Technology (DIT) to examine the numerical skills of first year Engineering students and ascertain if these skills had any impact on their ability to successfully pass the year. The results of this study showed a strong likelihood that students with low numerical skills would withdraw or fail to pass the year. Anecdotal evidence suggested that this was also becoming a problem in other faculties within DIT. As a result, it was decided to open the Students' Maths Learning Centre (SMLC) in DIT, with the aim of providing additional mathematical support in a relaxed, non-judgemental atmosphere for any DIT student whose programme contains a mathematical element. Maths learning centres are becoming more and more widespread in institutes of higher education across Ireland and the U.K. (Croft, 2000; Dalby, 2001; Lawson, Croft and Halpin, 2003).

DIT is somewhat uniquely placed in the third-level sector in Ireland, as its true nature lies somewhere between that of a university and that of an institute of technology. Numerous undergraduate programmes are offered at honours degree level, and there are a growing number of postgraduates involved in a wide variety of research, but there are also programmes for apprentices in various trades, along with higher certificates (diplomas) and ordinary degrees. As a result, the range and levels of maths studied within the institute are vast.

The DIT SMLC began on a small scale during 2004-2005, and opened across all relevant campuses and faculties during 2005-2006. DIT is a multi-campus institute, with campus locations spread across Dublin city centre. Given that many of these locations are over 30-40 minutes' walk from each other, it was important for the SMLC to develop a two-fold approach towards mathematical support, incorporating one-to-one tuition, through the form of drop-in sessions, with an e-learning support system, through

the provision of online resources in a password-protected WebCT intranet. Table 1 details the number of students who used the SMLC support services during the academic year 2005-2006. It is interesting to observe that over 70% of the students who attended the drop-in sessions did not make significant use of the online resources, indicating that many students have a clear preference for one type of support over another.

Table 1: Number of students who used the SMLC support services during 2005-2006.

SMLC Support System	Number of Students
Drop-in Sessions	544
WebCT	1177
(Overlap)	(150)
Total	**1571**

In this paper, we will begin by describing the nature of the drop-in sessions and the data collated on the students who attended. We will then go on to discuss the online resources provided by the centre, and finally, we will look at the most common problems observed across the entire student body.

2. Drop-in Sessions

DIT SMLC's drop-in sessions are three hours in length. Each campus has two three-hour sessions per week, with most of these centred around lunchtime or early evening, when students are most likely to be able to attend. Attendance is free-of-charge and no appointment is necessary. Central to the SMLC operational policy is that students *must* bring their lecture notes to each drop-in session. The reasons for this are two-fold: firstly, to ensure that appropriate and relevant material is covered with the student; secondly, to emphasise that the drop-in sessions are an additional support, not a substitute, for attendance at lectures and tutorials.

Within the drop-in sessions, the emphasis is on *independent learning* rather than "grinds". The approach is to assist students when they arrive by explaining the specific topic they wish to cover, usually giving a worked example of how to approach a problem, and then setting similar exercises for them to attempt. They are loosely supervised while working through these problems and thus can raise any issues they might encounter. In this way, it is possible for a single advisor to help several students with different topics at the same time, while the student develops greater confidence in his own ability to independently tackle mathematical problems. Students can also be introduced to the range of resources that are available to them at third-level, such as useful textbooks or websites.

Drop-in sessions run throughout the lecture term, as well as during exam periods, and through the month of August, prior to the repeat exams. Table 2 shows the number of new students who registered with the SMLC drop-in centre, as well as the total number of student visits, during each period of 2005-2006.

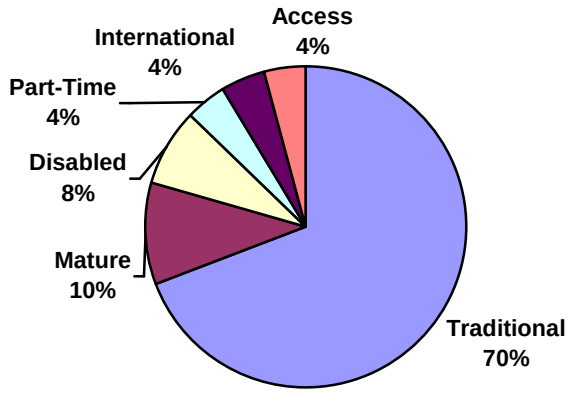
Table 2: Number of new students and overall student visits to the drop-in sessions, during lecture terms and exam periods for 2005-2006.

		Number of New Students	Number of Visits
1st Lecture Term	(19/09/05 – 16/12/05)	110	260
1st Exam Period	(03/01/06 – 27/01/06)	61	115
2nd Lecture Term	(30/01/06 – 12/05/06)	242	602
2nd Exam Period	(15/05/06 – 31/05/06)	57	111
Repeat Exam Period	(08/08/06 – 06/09/06)	74	218
Total		**544**	**1306**

DIT is in the process of converting to a fully semesterised calendar, meaning that there will be exams in January and again in May. In 2005-2006, approximately half the programmes had been semesterised, while the other half were examined only at the end of the year. It is interesting to observe the high attendance levels during the first exam period, in January, given that far fewer students had exams at this time. However, the exams took place directly after the Christmas holidays, and most students had no opportunity to clarify with lecturers problems that had only arisen over the holiday period once they began their revision in earnest, and so attended the SMLC in large numbers for assistance at this time. It is also instructive (if not altogether surprising!) to note that the vast majority of the visits that took place in August prior to the repeat exams were by students who had *not* attended the SMLC during the academic year.

On average, students spent between 50 minutes and 2 ¼ hours in the drop-in centre per visit. A large proportion of these students (44%) were first-years, but almost half (48%) were from second or third year, showing a clear need for continued support throughout their college experience. As can be seen from Figure 1 below, 30% of those attending the drop-in sessions are classified as "non-traditional" entrants, including mature students, students with a disability, part-time students, international students and Access students.

Figure 1: Number of traditional and non-traditional entrants who attended SMLC drop-in sessions in 2005-2006.



Traditional learners attend the centre for a multitude of reasons: some need weekly support in order to cope in lectures; others simply require clarification of a single topic. For non-traditional learners, the issues are often more complex. Because many mature students have not studied maths in some time, they often need specific help in revising

basic topics at the start of the year. They tend to lack confidence in their own abilities, but are extremely motivated and eager to learn. Almost all of the students registered with the Disability Service who attend the drop-in sessions are dyslexic, and as such, face particular challenges in maths. They frequently have difficulty transcribing mathematical symbols in lectures, where as little as one incorrect letter in an equation can render it unintelligible. Such students can often be provided with printed revision notes from the SMLC, or can cover topics at a slower pace, using more visual imagery, when working one-to-one with an SMLC advisor. Part-time students, for whom time is of the essence, often cannot attend drop-in sessions, as many work full-time. Instead, they tend to avail of the e-learning resources. For international students, problems can arise when they have not previously covered the necessary background topics to follow class material or have difficulty adjusting to terminology in English. Access students, who come from socio-economically deprived backgrounds, often need additional support adjusting to third-level.

Given the wide variety of maths covered in drop-in sessions, it is interesting to look at the topics most commonly covered. Table 3 gives an ordered list of the twenty most common areas that cause problems for students, along with the number of student visits in which this topic was covered.

Table 3: Breakdown of the twenty most common topics covered with students in drop-in sessions, along with the number of student visits that addressed each topic.

Topic	Number of Visits	Topic	Number of Visits
1. Basic Integration	121	11. Compound Interest	40
2. Basic Differentiation	90	12. Logs	35
3. Measure of Central Tendency	82	13. Differential Equations	35
4. Normal Distribution	64	14. Binomial Distribution	33
5. Probability	60	15. Matrix Inversion	32
6. Area/Volume/Density	53	16. Index Numbers	31
7. Binomial Expansion	43	17. Determinants	30
8. Basic Matrices	43	18. Eigenvalues	29
9. Linear Programming	43	19. Poisson Distribution	29
10. Linear Regression	40	20. Partial Fractions	28

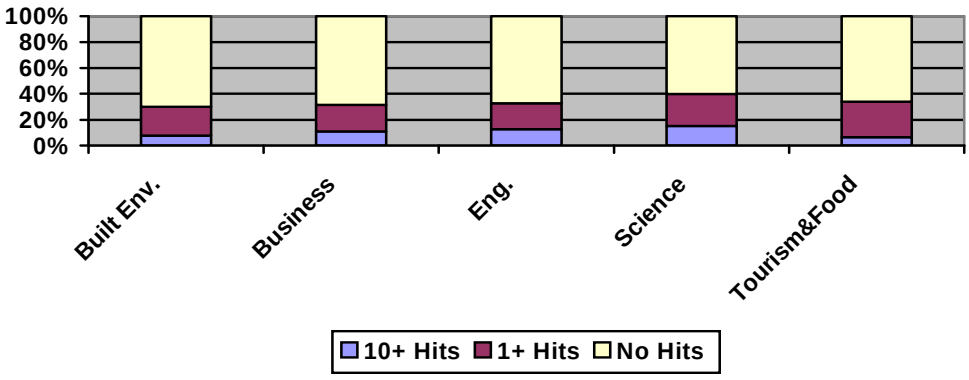
However, it should be noted that some topics in this list are specific to certain programme types – for example, area/volume/density appears to be one of the most common problem areas, but in fact, this was simply due to the regular attendance of numerous apprentices from the Carpentry and Joinery programme. Both integration and differentiation cause difficulties for most student groups, as does basic statistics, in particular such areas as measures of central tendency, normal distribution and probability.

3. Online Resources

As mentioned earlier, DIT has introduced WebCT, a password-protected intranet, as part of its e-learning resources for students. The SMLC has a separate WebCT site for each faculty, to allow the mathematical resources to be tailored to best suit the specific

needs of students from each discipline. Each site contains revision notes, self-tests on problem areas, recommended textbooks and websites, relevant mathematical articles and general information about the centre. In addition, the SMLC has a website, with much of the same resources available to students. Figure 2 shows the percentage of students in each faculty who accessed the SMLC WebCT site on at least one occasion (meaning that they know it exists and how to use it), and those who made significant use of the resources (where ten or more hits are considered significant). A total of 3616 students used the resource at least once, while 1177 made significant use of the WebCT service.

Figure 2: Percentage of students from each faculty who accessed the SMLC WebCT site at least once, and those who made significant use (10+ hits) of the site.



A closer look at the students who made the most use of the online resources (50+ hits) reveals that not a single one of them ever attended a drop-in session, showing a very strong preference for online support instead. There are numerous reasons why students may prefer online resources: it allows them to freedom to study late at night or at weekends; for part-time students, with lectures several nights a week and a full-time job during the day, it may be the only support system they can realistically use; it grants the student a certain anonymity, meaning that they do not have to openly admit to having difficulties; because of the multi-campus nature of DIT, it allows students to access help whenever they need it, even if there is no drop-in session on their campus that day.

Most of the revision notes on WebCT are taken from the Mathcentre website (http://www.mathcentre.ac.uk/) (with the kind permission of Dr. Tony Croft), which is an online collaboration between the Universities of Loughborough, Leeds and Coventry, the Educational Broadcast Services Trust and UK Learning and Teaching Support Networks. It consists of a series of two-page summaries on various important topics from first-year maths, including examples, exercises and solutions. Extra notes produced in DIT are included on WebCT where necessary. Table 4 gives a breakdown of the twenty most common topics accessed on the SMLC WebCT site. To compile this list, the pages that received the most hits must clearly be considered. However, the length of time per hit is also relevant, to ascertain if students are studying the material on the page or simply browsing. Therefore, the topics in Table 4 have both a high number of hits and a long mean time per hit.

Table 4: Breakdown of the twenty most common topics studied by students on the SMLC WebCT site. The list is based on topics that have both a high number of hits and a long mean time per hit, as this suggests that students are studying rather than browsing the topic.

Topic	Topic
1. Basic Integration	11. Median and Mode
2. Basic Differentiation	12. Poisson Distribution
3. Chain Rule	13. Mean and Variance
4. Drawing Graphs	14. Scatter Diagram and Regression Line
5. Complex Numbers	15. Introductory Mathematics
6. Tangents, Max/Min	16. Fractions and Percentages
7. Basic Functions	17. Fourier Series
8. Integration using Partial Fractions	18. Differentiation with Two Variables
9. Basic Matrices	19. Getting Started with Matlab
10. Binomial Distribution	20. Getting Started with Derive

It is too early to produce any definitive comparison between the topics studied online and those studied in drop-in sessions, as the online resources are not yet sufficiently developed. However, based on the data acquired from drop-in sessions, it is intended to produce more extensive online support in the coming year, which will facilitate more accurate comparisons in years to come.

One area of difficulty that should be mentioned in relation to providing online mathematical support is that it is extremely difficult to incorporate interactive learning for students, particularly for a maths learning centre. Most online environments are not well adapted to maths (Leventhall, 2004; Smith and Ferguson, 2005) and it can be particularly challenging for students who already experience problems with maths to learn different methods of producing the necessary maths notation online. As a result, any self-tests that are provided online must be of a multiple-choice variety, which is not ideal, and it is almost infeasible to interact online with students who may not be able to attend drop-in sessions. There is a real need for a software tool that allows mathematical interaction to take place without the current difficulties.

4. Common Problems and Possible Solutions

In the course of working with such a diverse body of students, it became apparent that certain issues present difficulties for a wide range of individuals. Some such issues are listed below, along with the approach taken by the SMLC to attempt to alleviate these problems.

a) Problems with terminology

It has been observed that students attending the drop-in sessions are often unfamiliar with the *name* of the topic with which they wish to request help. Students are particularly prone to confusing the terms “differentiation” and “integration” and tend to use these interchangeably. This is not a major difficulty in drop-in sessions, as it is possible for the SMLC advisors to look at the student’s notes and determine what topic is involved; however, it raises a grave concern about the ability of weaker students to effectively use online resources such as the SMLC WebCT site, in which they must select the topic they wish to study from a list.

Possible solutions: If students attend the drop-in sessions, an effort is made to explain relevant terminology where appropriate. To address the online issue, a number of self-tests have been developed within the SMLC and made available for students on WebCT. These tests consist of multiple-choice answers to questions in specific areas of mathematics and are immensely popular with students. If a student answers a question incorrectly, a message appears directing them to the number and title of the worksheet they should study in order to gain a better grasp of the topic in question. In this way, weaker students can be guided towards the online resources most suitable for their needs.

b) Confusion about basic mathematical principles

A large proportion of the students attending the SMLC drop-in sessions have difficulty with concepts such as balancing equations, removing brackets, cancelling or cross-multiplication. However, they rarely seek help for these specific problems, seeming to be largely unaware of their difficulties with such concepts.

Possible solutions: When covering other topics in drop-in sessions, basic revision sheets are introduced whenever a student makes an error in one of these areas. In addition, a self-test has been developed on WebCT testing students' basic skills; often, students are taken aback at the number of mistakes they make in "simpler" maths, and are encouraged to attempt some suitable worksheets to rectify the problem.

c) Difficulty using calculators

Students rely on calculators for even the simplest of calculations (e.g. 1* ½); unfortunately, many have no idea of the *scale* of answer to expect and so, even if they mistype a calculation, will faithfully transcribe the answer they obtain. Mature students often lack confidence in their abilities to use calculators, due to the fact that they would not have done so during their school experience.

Possible solutions: Where possible, students are encouraged to estimate the size of the answer they would expect before performing the calculation. Students are also encouraged to practice numerous examples of particular calculations if they are unsure of how to proceed. In addition, specific guidelines for the most suitable calculators for dyslexic students (Trott and Beacham, 2005) are available in drop-in centres and online.

d) Negative attitude towards mathematics

Poor self-confidence in their own mathematical ability adversely affects students' abilities to succeed in the subject. This negative attitude is prevalent in most aspects of society and therefore impacts students in all faculties and levels.

Possible solutions: In order to increase students' confidence, problems are introduced in a graded fashion, allowing the student to experience success in solving these without help. Where possible, the SMLC attempts to link the maths being studied with the student's future career, to make it more relevant to their lives outside college. In addition, with the help of resources such as Plus magazine (http://plus.maths.org/), the numerous exciting uses of maths in everyday life are highlighted, to improve attitudes towards the subject.

5. Conclusion

Given that the SMLC is still in its infancy, a detailed analysis of the results of students who attended the centre regularly is not yet available, but it is proposed to produce this in the near future. Anecdotal evidence suggests that many students have benefited greatly from their use of the centre, and improved attitudes towards mathematics have been observed in students who attend regularly. There is a real need for additional mathematical support for a large number of students in third-level education, as evidenced by the students' voluntary usage of the SMLC in DIT and we hope to further pursue this work in the coming years.

References

Costello, F. and Russell, M. (2002) *Numerical Skills and Retention Rates Amongst First Year Students in the Faculty of Engineering.* Internal Report, Student Retention Office, Dublin Institute of Technology.

Croft, A.C. (2000) *A Guide to the Establishment of a Successful Mathematics Learning Support Centre.* International Journal of Mathematical Education in Science and Technology, 31(3):431-446.

Dalby, T. (2001) *Theory and Practice of Teaching in a University Mathematics Learning Centre.* International Journal of Mathematical Education in Science and Technology, 32(5):691-696.

Lawson, D., Croft, T. and Halpin, M. (2003) *Good Practice in the Provision of Mathematics Support Centres*. http://www.mathcentre.ac.uk/resources/guides/goodpractice2E.pdf, Last Accessed: 26/09/2006

Leventhall, L. (2004) *Bridging the Gap between Face to Face and Online Maths Tutoring*. Paper presented at the International Congress of Mathematics Education-10, Copenhagen, Denmark. http://dircweb.king.ac.uk/papers/Leventhall_L.H.2004_242915/leventhall_ICME10.pdf, Last Accessed: 26/09/2006

Smith, G.G. and Ferguson, D. (2005) *Student attrition in mathematics elearning*, Australasian Journal of Educational Technology, 21(3), 323-334. http://www.ascilite.org.au/ajet/ajet21/smith.html, Last Accessed: 26/09/2006

Trott, C. and Beacham, N. (2005) *Guidelines on Choosing a 2-line Scientific Calculator for Dyslexic Students.* Loughborough University, October 2005. http://ddig.lboro.ac.uk/documents/calculator_guidelines.doc, Last Accessed: 26/09/2006