Supporting Engineering Students within a Maths Learning Centre Environment

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Abstract

In 2002, a study conducted within Dublin Institute of Technology (DIT) examined the numerical skills of first year engineering students to ascertain the impact of these skills on their ability to successfully pass the year. The results showed a strong likelihood that students with low numerical skills would withdraw or fail to pass the year. DIT is a multi-level institute, offering engineering programmes at levels six, seven and eight, and also incorporating a "ladder system", which allows students who perform sufficiently well at one level to proceed into the next. As a result, students of different educational backgrounds often find themselves in the same mathematics module. Anecdotal evidence indicated that particular difficulties were experienced by students who, having completed a level seven programme, proceeded directly into third year of a level eight programme, where a significantly higher level of maths was suddenly demanded. As a result of these, and other, issues, the Students' Maths Learning Centre (SMLC) was established to provide additional mathematical support for DIT students. Last year, one in ten students from the Faculty of Engineering availed of the SMLC's drop-in service, with almost a fifth of engineering students making significant use of the SMLC's online resources. In this paper, we identify the most common problem areas in maths for DIT engineers at various levels, along with the most useful resources for these topics. We also consider the possible effects of semesterisation on the learning of mathematics for engineers, based on patterns of attendance over the past couple of years.

Introduction

In 2002, the Retention Office in Dublin Institute of Technology (DIT) completed a study (Costello, 2002) aimed at determining whether poor numerical skills on entry were a strong predictor of failure to pass first year engineering. The results unsurprisingly showed that those with low scores in this area were highly likely to withdraw before the terminal examinations, or fail to pass the year overall. In interviews conducted with some of these students, a significant portion professed themselves to be taken aback at the strong mathematical content of an engineering programme, and felt themselves to be completely unprepared for the level of mathematics they would be studying.

DIT is in a somewhat unique position in Ireland, as it offers a wide range of engineering programmes (both full-time and part-time) at levels six, seven and eight (namely Higher Certificates, Ordinary Degrees and Honours Degrees), as well as incorporating a "ladder system" which gives students the opportunity to progress from one level to the next, provided they have performed to a sufficiently high standard. As a result, engineering students within a single mathematics module will often be from varying educational backgrounds, even in relation to their third-level mathematics learning, which creates an even greater challenge for educators. Anecdotally, it had been observed that students

who had successfully completed a level seven programme and subsequently entered directly into the third year of a level eight programme experienced considerable difficulties with the mathematics component, although they tend to cope well with the more practical elements of the programme.

As a result of these, and other, concerns, DIT followed in the footsteps of numerous other third-level institutes (Lawson, 2003), both in Ireland and the United Kingdom, and established the Students' Maths Learning Centre (SMLC) during the academic year 2004-2005 (Ní Fhloinn, 2006), with the aim of providing additional mathematical support for students from any faculty in DIT whose programme contained a mathematics module.

Students' Maths Learning Centre: Supporting Engineers

DIT is a multi-campus institute, with the main campus buildings located on different sites around Dublin city centre. In addition, resources for the SMLC were limited, so a two-fold approach was deemed the most effective, incorporating one-to-one help through the form of drop-in sessions, along with e-learning support via a WebCT site. There are three main campus sites at which one-to-one support is provided, with between six and nine hours drop-in service available in each, in three-hour blocks. In order to best facilitate engineering students, who have a full timetable of lectures and labs, drop-in sessions are held during lunchtime hours or from 4:00-7:00 in the evening, when most students are available.

Due to budgetary constraints, there is usually only one advisor present in a drop-in session to help students. As a result, easy availability of relevant resources within the centre has been crucial, allowing students to be more independent in their learning: as such, the revision sheets from the Engineering Maths First Aid Kit from the Mathcentre website (http://www.mathcentre.ac.uk) have proved invaluable. Mathcentre is an online collaboration between the Universities of Loughborough, Leeds and Coventry, the Educational Broadcast Services Trust and UK Learning and Teaching Support Networks. The Engineering Maths First Aid Kit consists of a series of two-page summaries on various important topics from first-year maths, including examples, exercises and solutions. Having assessed the students' needs, the SMLC advisor can provide them with relevant revision sheets to work through in the centre, allowing them to gain in confidence as they successfully complete certain exercises, while still having the reassurance of an advisor present should they struggle with any concept.

As the SMLC became more established, the number of students using the service continued to rise. In the academic year 2006-2007, over half the students who used the centre's drop-in facility were from the Faculty of Engineering, with one in ten engineering students availing of the service. This amounts to a total of almost three hundred engineering students, from all years and programme types – an increase of more than one hundred students on the previous academic year.

In addition, almost one fifth of engineering students made significant use of the WebCT service (with "significant use" being defined as ten or more hits on the site). A separate WebCT site was designed for each faculty, so that the resources and information could be tailored to best suit the specific needs of students in that discipline. Each site contains revision notes, self-tests on problem areas, recommended textbooks and websites, relevant mathematical articles and general information about the centre. For the Faculty of Engineering, the Engineering Maths First Aid Kit was included, grouped by topic (with the kind permission of Dr. Tony Croft). Selected articles about the use of maths in engineering applications, taken from Plus magazine (http://plus.maths.org) were also uploaded, to emphasise to students the importance of the maths they were studying, and also expose them to some more unusual and interesting applications.

Most Common Problem Areas

Each time that a student attends a drop-in session, the advisor present makes a note of the topics covered. As a result, the most common problem areas for which engineering students seek help in the SMLC can be determined. Table 1 below shows the top fifteen problematic topics, along with the number of visits in which these topics were addressed, during the academic year 2006-2007.

Table 1: Most common problem areas for engineers who sought help in the SMLC during the academic year 2006-2007.

Problem Area	Number of Visits
1. Laplace Transforms	75
2. Basic Integration	68
3. Basic Differentiation	58
4. Differential Equations	55
5. Matrix Arithmetic	49
6. Fourier Series	47
7. Eigenvalues	40
8. Transposition of Formulae	39
9. Complex Numbers	34
10. Logs	30
11. Basic Trigonometry	28
12. Binomial Theorem	24
13. Normal Distribution	23
14. Partial Fractions	23
15. Runge-Kutta	20

From this list, it is clear that certain areas which are entirely new to students in third-level, such as Laplace transforms or Fourier series, cause considerable difficulties; but it is striking that the majority of the areas listed above are ones with which students should be highly familiar prior to coming to third-level (for example, basic calculus, transposition of formulae and basic trigonometry).

Effects of Semesterisation on Patterns of Attendance

As well as considering the topics with which engineers have difficulty, it is also of interest to look at attendance patterns in the drop-in centre over the past two years. Recently, DIT has changed to a fully modularised, semesterised calendar, with two exam periods per year, in January and May. This change was undertaken on a phased basis over two years; in 2005-2006, two teaching semesters of twelve weeks (with an additional "review week" after week six) were introduced; however, some programmes did not introduce modularisation or semesterised exams until the following year. Most engineering programmes took the latter approach, allowing us to review any differences between the patterns of attendance at the drop-in sessions between the two years, and offer possible explanations for these differences. Although more data would be necessary to draw any firm conclusions about the effects of semesterisation on attendance or study patterns, an initial analysis is of interest at this point.

The SMLC drop-in sessions ran every week (including review week) for both semesters. In addition, special sessions were run three days a week during the two-week Easter break in second semester, as well as the week prior to the January exams, and for the full two weeks of each exam period.

It should be borne in mind that there was a natural increase in the number of engineering students who attended the SMLC, as well as the frequency of their visits, between 2005-2006 and 2006-2007. However, although the number of visits increased by 61%, this drops to an increase of 21% if exam weeks are excluded. Therefore, we begin by considering the exam weeks in isolation.

Attendance during Exam Periods

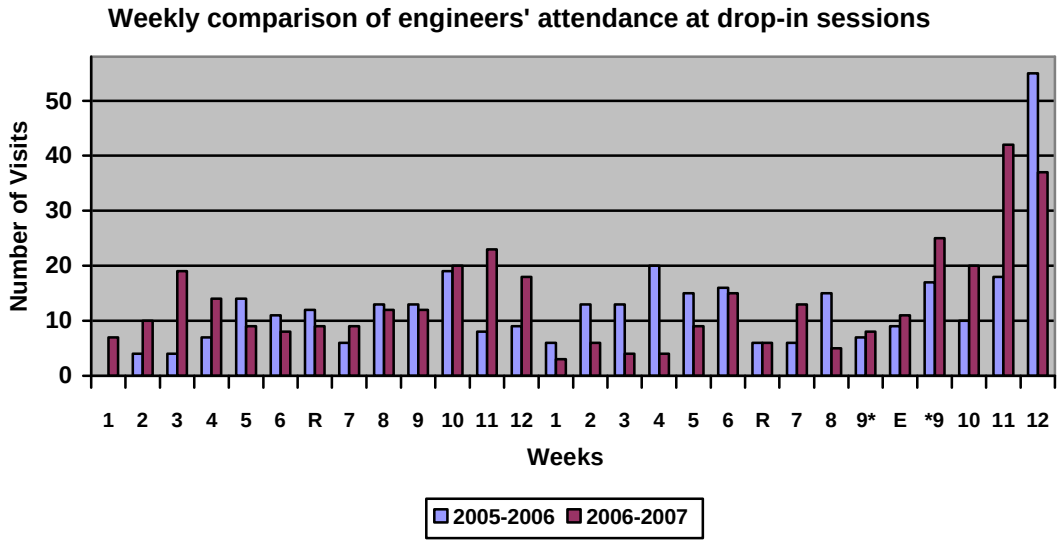
The January exam period was the busiest time of 2006-2007; students were on holidays from mid-December, returning in early January to face exams, but without having had contact with their lecturers in the meantime. The SMLC was open for three days prior to exams commencing, during which there were 117 visits from engineers, with a further 76 visits the following week. Some students were well-prepared and attended only to clarify small points, but the majority sought considerable help. It is not particularly relevant to compare these numbers with those of the previous year, as there were far fewer exams at that stage; but it is striking that the average number of visits per week from engineers in the first semester of 2006-2007 was just thirteen.

The May exam period showed a less extreme variation (though still busier than the previous year), with 46 visits the first week and 26 the second week. This can largely be attributed to the fact that students had full access to lecturers, tutors, library facilities and the SMLC in the direct run-up to these exams and seemed to begin their study at an earlier stage, perhaps due to this being ingrained as a more traditional exam-time!

Attendance during Semesters

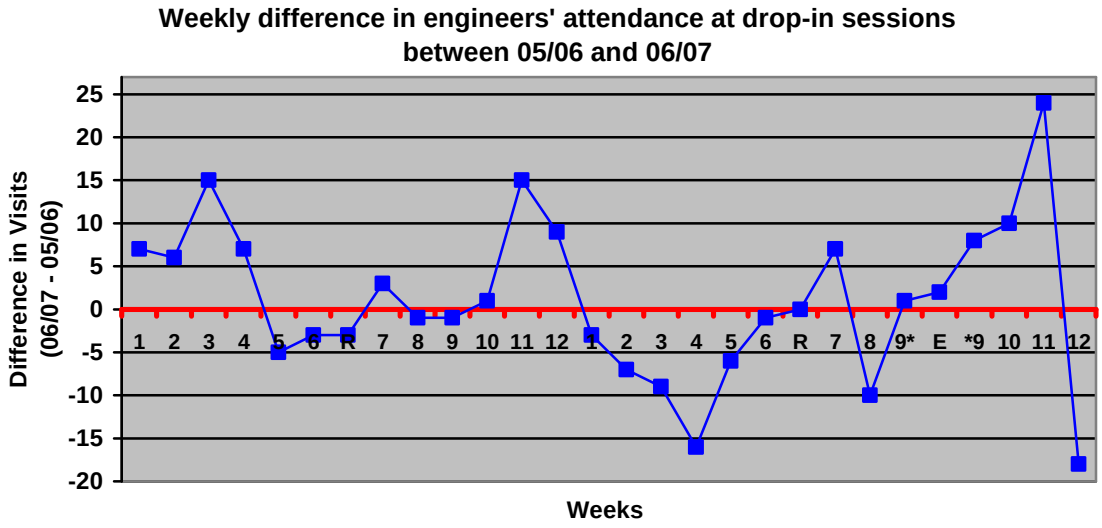
Figure 1 overleaf compares attendance during semesters by week, omitting exam weeks.

Figure 1: Weekly comparison of attendance of engineers at drop-in sessions during 2005-2006 and 2006-2007. "R" is "review week", when students have no lectures; "E" is Easter holidays; "9*" is week 9 in 2005-2006, but week 1 of Easter holidays in 2006-2007, while "*9" is week 2 of Easter holidays in 2005-2006, but week 9 in 2006-2007.



As we are specifically interested in changes in patterns of attendance, Figure 2 is useful in showing exactly that; it was generated by subtracting the weekly visits in 2005-2006 from those in 2006-2007. Therefore, the portions of the graph in which the blue line is above the red zero line represent an increase in 2006-2007 over the previous year.

Figure 2: Weekly difference between attendance of engineers at drop-in sessions during 2005-2006 and 2006-2007. The same abbreviations apply as for the previous figure.



It should be stated that the weekly differences are generally not that extreme, as we are looking only at engineering students and subsequently, weekly numbers are not that high. In addition, some spikes can be explained by in-class tests, for example, in week 7 of the first and second semesters, and week 11 of first semester. However, it would have been expected that 2006-2007 would have shown higher attendance almost every week, given that students were better aware of the facility, and many would have attended the previous year. Instead, taking both graphs together, a distinct drop can be seen, most notably at the start of the second semester: this can partially be explained by the fact that some students would have started new modules at this point; however, the majority of engineering maths modules are year-long ones, which suggests that it may take students some time to settle back into study following the January exam period.

Many third- and fourth-year students sat their terminal maths exams in January; however, although they attended in huge numbers immediately prior to the exam, the majority had not attended during the first semester, suggesting a reliance on last-minute studying, even for students in the later years of their degrees. Anecdotally, the previous year, these students attended for several weeks prior to exams, allowing deeper learning to take place. This is not to say that semesterised exams have a negative impact on student learning of mathematics, but merely to suggest that some students may need a shift in thinking now in order to make best use of the support systems in place.

Conclusion

In this paper, we have described the daily operation of the Students' Maths Learning Centre in DIT, and specifically, its work with engineering students within the institute. We have identified the most common problem areas for engineering students, along with the resources we have found most useful. In addition, we have looked at the possible effects of semesterisation on attendance patterns in the SMLC; these effects may become more discernable in the coming years as more data becomes available.

References

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