Investigating UK undergraduate electrical and electronic engineering attrition

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Abstract A 2001 UK survey of electrical and electronic engineering academics looked at undergraduate attrition rates against the background of quantifiable 'resource' measures such as staff-student ratio and admissions criteria. Whilst there are predictable *trends* relating achievement to such parameters, the variation in progression statistics between higher education institutions with similar 'resources' was large, implying scope for improvement by adoption of appropriate practices. Respondents furnished information on subject matter problematic to their students, and outlined departmental strategies for counteracting attrition. Pastoral care issues, such as financial problems, disability, gender and ethnicity were also discussed.

Keywords attrition; student support; progression; undergraduate

The Electronic Engineering Progression Issues Survey was conducted as a baseline for the PROGRESS FDTL3 Project (funded by the Higher Education Funding Council for England) which has a broad remit to examine both the causes of attrition in electrical and electronic engineering, and to disseminate effective strategies for mitigating it, through development partnerships with pro-active higher education institutions (HEIs) around the UK. Approximately 60% of the 75 institutions canvassed returned data, with a balance of pre- and post-1992 institutions (22 and 20 respectively).

The aim of the PROGRESS project is to improve levels of student success in programmes of study in electrical and electronic engineering. Within this aim we are seeking to achieve the following objectives:

1 establish the current situation in terms of student failure rates for HE electronic engineering programmes, including the identification of problematic subject matter and the influence of student perceptions and pastoral care issues;
2 identify a range of strategies which appear to have been successful in improving student progression and completion rates;
3 enhance and evaluate these strategies in collaboration with innovative institutions;
4 assemble and disseminate a toolbox of techniques for enhancing student progression and achievement;
5 develop a network of consultants who can advise and assist institutions in implementing these techniques.

The survey work discussed here relates to objectives 1, 2 and 5 above.

The survey was also useful as an objective assessment of the degree of awareness and innovation within specific institutions in respect of student achievement, as a basis for future development of support networks.

A snapshot of progression issues in UK electronic engineering

Each HEI has its own unique mix of parameters which affect the success or otherwise of students embarking on engineering programmes. At first sight it is not obvious how to extract common threads of the experience of both learners and teachers from the panoply of factors at play. If the PROGRESS project is to produce useful outcomes, the first stage is the characterisation of the situation 'on the ground', in terms of the extent of the problems encountered and the strategies ranged against them by the academic community. This will give an objective basis for targeting the resources of the project where they will be employed to best effect.

One aspect of the survey was to measure the extent of the problem of student attrition and to look for correlation with easily identifiable 'resource parameters', such as

- the capability of the students when they start their course, as measured by admissions criteria and average actual grade score on entry;
- the amount of staff resource available for teaching and learning support;
- the amount of guided study time the student engages in per week.

As we shall see, although some trends are identifiable – largely obvious, such as HEIs with high admissions requirements tend to suffer lower attrition rates – the variability amongst HEIs from trend is so large as to suggest that there is nothing pre-ordained about student progression by resource issues. This is a message of hope!

The response to the challenge

All HEIs have recognised the demands on the teaching and learning process engendered by changes in the pre-university curriculum and the widening of participation at tertiary level. This is in an environment where the admissions in 'hard' science and engineering disciplines have remained static or even declined, to the extent that there now exist significant skills shortages in the UK employment market.[1,2] It is arguable that this represents a dilution in the pool of talent entering such disciplines, to the extent that there is a significant mismatch between the expectations which can be placed on learners' abilities and motivation between the present time and even a decade ago.[3,4] This is reflected in the experiences of the students themselves, as reported in the companion survey to this one, also conducted under the PROGRESS project, by Forsey and Marshall,[5] and in the extensive work of Yorke.[6]

The survey sought to elicit information in respect of:

- identification of subject matter within the range of electronic engineering (and related) programmes which persistently proved problematic to student progression;
- the awareness of the teaching community of non-academic difficulties (disability-, ethnicity-, gender-related etc.) having impact on progression;
- the extent of guidance and support for non-completers of programmes, toward transfer opportunities or alternative career paths;

- descriptions of teaching and learning strategies which have been employed to support students in respect of problem subjects or personal difficulty, together with an estimation of their effectiveness and the reaction of the students;
- the extent to which the institution would be prepared to engage in collaborative development and dissemination work with the PROGRESS project.

The pool of resources

The phenomenon of generally declining standards of achievement in engineering is not particularly new, having been recognised in the UK and abroad, particularly the United States, for many years. From the perspective of the PROGRESS project, this recognition is useful since many institutions are already deeply engaged with the problem and are experimenting with innovative techniques to enhance the student learning experience. The purpose of the project is not to 're-invent the wheel' but to gather and disseminate information about what works effectively (and what doesn't!) in a manner which is credible and accessible to the wider academic community.

The survey's fact-finding structure had an overlaying scoring system which helps to quantify the potential for each institution's contribution to the project. The reason for this is to make an objective measure of the totality of expertise available, so that further research, development and dissemination work could be focussed where maximum benefit could be derived for the project and its intended beneficiaries. This measure can be used to identify institutions for future collaborative development work. This information will, of course, be augmented by further investigations, not least by incorporating the contributions of individual academics to this journal special issue.

Methodology

Given the well-known workload pressures and excessive volume of paperwork flooding the desks of the academic community, it was decided that the survey should be designed to maximise response rate, minimise time demands and eliminate the need for additional work by the recipient. This was approached as follows.

- The survey was targeted on academics known to be pro-active in teaching and learning issues and in regular contact with students at the appropriate level – located by personal contact, desk research or through existing networks (e.g. LTSN Engineering). Such individuals (e.g. year tutors or programme leaders) would have a working knowledge of the pertinent issues and statistics without having to engage in additional intra-departmental investigations. Whilst pre-selecting a sub-section of the academic community could engender bias in the responses, we feel that the predominantly factual (rather than opinion) basis of the survey in respect of reporting the state of student progression issues in electrical and electronic engineering minimises the significance of the inevitable bias of this selected group.
- The means of conducting the survey was by telephone, using a structured interview script but allowing open-ended responses to enquiries. The duration of the

telephone interview was usually 15–25 minutes, depending on the level of detail given by the respondent.

- Questions requiring factual responses were couched in terms aiming to compromise between accessibility of data and its ultimate utility. For example, respondents were not expected to give attrition rates to a precision of better than one per cent. Further, in addressing the issue of problematic subject matter, specific module titles were not sought due to the inherent variability in content between institutions – rather generic topic names such as *analogue electronics* were acceptable.
- Data was collated and integrated into spreadsheets and charts summarising the quantitative information, and a database/tabular forms for qualitative responses. Much of the qualitative data is highly context-sensitive, but headline issues have been extracted in order to illustrate trends at a superficial level. The qualitative database will evolve into a project resource eventually as a searchable archive of expertise across the HE sector.

Findings

As mentioned in the introduction, we investigated simple quantitative measures which might show whether 'resource' issues showed direct correlations with attrition rates. Although we collected both year 1 and year 2 data, year 1 data only is included due to space restrictions.

Attrition is plotted as dependant variable against a variety of such 'resource' parameters. Linear regression trend lines are included only as an indicator of data variability, as the correlation is manifestly very low.

Admissions criteria

The height of the admissions barrier is clearly a *possible* determinant of student achievement – do high achievers at 'A'-level translate into successful university-level engineering students? The general answer, as seen from the trend line in Fig. 1, is positive; those institutions which set high admissions score criteria are clustered at the lower attrition values, and vice-versa. However, the enormous positive and negative scatter on the attrition rates in evidence around the mid-band of admissions points (around the SARTOR BEng threshold) suggests that it is 'nurture rather than nature' – the experiences of students *after* they begin their undergraduate programme – which is important in this respect.

Of course, admissions criteria as stated in the *UCAS Handbook* do not always translate into the actual average grade score of the students on arrival. Figure 2 shows a similar correlation for attrition rate with departmental grade averages as stated in *The Times e-Services on-line database.*[7] (Not all institutions are represented in this source, therefore the points are a sub-set of the collected data.)

It is worth noting that the trend-line is steeper in Fig. 2, shifted down by about 4% in high-score range (~25 points), about 3% at the mid-band (~18 points) between the two graphs. One explanation of this is that institutions will often accept students

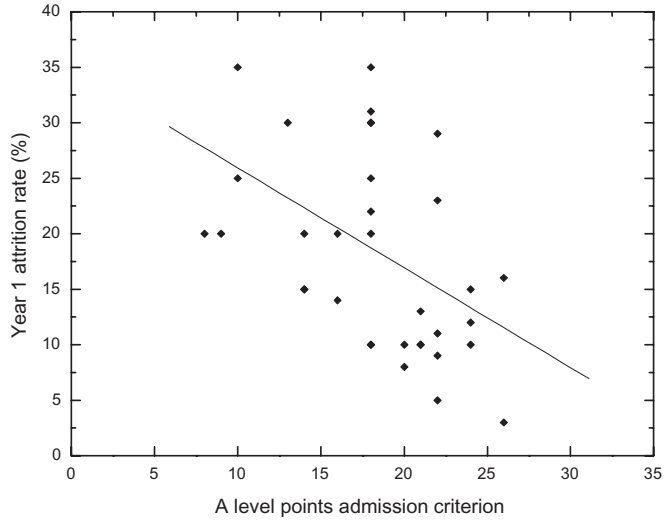

Fig. 1 *Correlating BEng and MEng admissions criteria with year 1 attrition.*

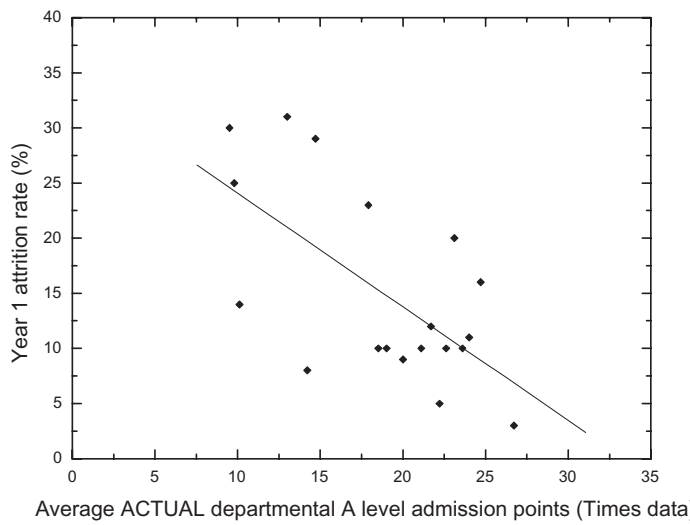

Fig. 2 *Correlating BEng and MEng admissions scores with year 1 attrition rates (source: The Times e-Services[7]).*

for entry with 'A'-level scores below their UCAS criteria, which skew the correlation. Interestingly, in the lower ranges (~10 points), the discrepancy in progression rate becomes very small – possibly due to there being very little elasticity in this baseline.

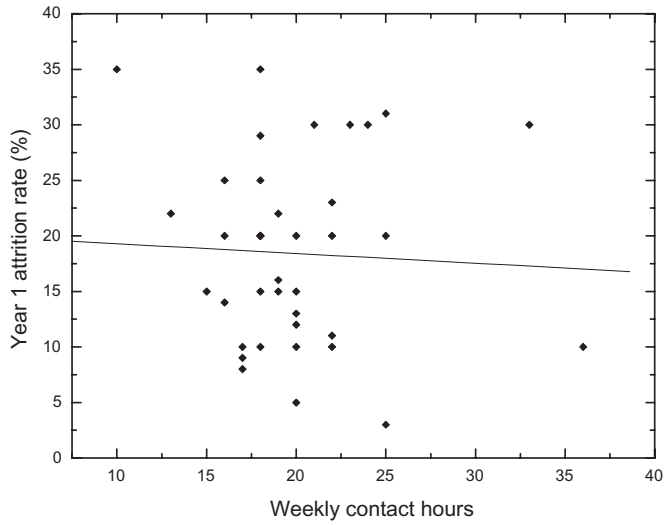

Fig. 3 *Correlation between weekly guided study duration and attrition rate.*

Contact hours

There is enormous variability in guided study time undertaken by students in the working week, ranging from 10 to 36 hours. Yet there is almost no systematic impact made on attrition rate by long periods of guided study, evidenced by the near-horizontal trend line (Fig. 3).

This supports the contention that lowering attrition need not be resource-intensive.

Student/staff (FTE) ratio

It might be argued that greater levels of personal attention from academic staff would lead to higher levels of achievement, whether through enhanced learning, greater student motivation or resolution of pastoral care issues. The trend line in Fig. 4 shows that, on average, halving the student/staff ratio should yield a 25% reduction in attrition, over the main range of SSR = 10 to SSR = 20. The variability in progression rate against SSR is so huge that this 'human-resource factor' cannot be isolated as determinant of progression. The source of this variability at the local level will depend upon staff workload factors outside teaching and pastoral care, such as research activity and administrative duties. On the other hand, it is self-evident that some institutions are more effective than others in respect of student progression rates for a given SSR. Therefore, it may be inferred that there is scope for improvement in many cases, even with constrained staff resources.

Summary attrition data for pre- and post-92 universities

Whilst the data confidentiality conditions of the survey preclude publication of the attrition statistics of individual institutions, it is of interest to compare and contrast

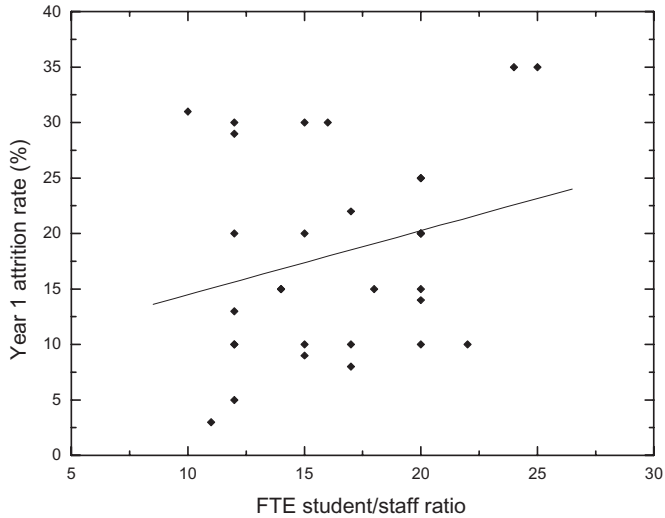

Fig. 4 *Correlation between student/staff ratio (FTE) and year 1 attrition rates.*

the aggregated statistics for the pre- and post-92 universities for all electrical and elecronic engineering programmes.

Pre-92	**Year 1:** 15.5% (mean) [range 3–31%]	**Year 2:** 6.7% (mean) [range 1–26%]
Post-92	**Year 1:** 21.8% (mean) [range 10–35%]	**Year 2:** 9.1% (mean) [range 1–27%]

A detailed discussion of the disparity observed is beyond the scope of this paper, but could possibly be attributed to factors such as the legacy of lower 'A'-level scoring applicants (from previous polytechnic status), higher levels of part-time and mature students, higher SSR, etc. in the post-92 sector.

Qualitative data – problematic topics

During the survey respondents were asked to identify five problematic subject areas for students in each of year 1 and year 2 of their electrical and electronic engineering programmes. Interestingly, over the 42 surveys analysed, the list of topics is quite short, and overwhelmingly dominated for *both* years by the subject of mathematics and by subjects with a high mathematical/abstract content such as electromagnetism. Note that the reporting frequencies are absolute, and therefore each category has maximum frequency of 84, as the survey covered 2 years. Therefore mathematics is reported as problematic in 67% (56/84) of circumstances.

Qualitative data – minority group pastoral care issues

Five areas of minority pastoral care were addressed by the survey – primarily to flag up specific expertise in particular areas which could be of benefit to the PROGRESS

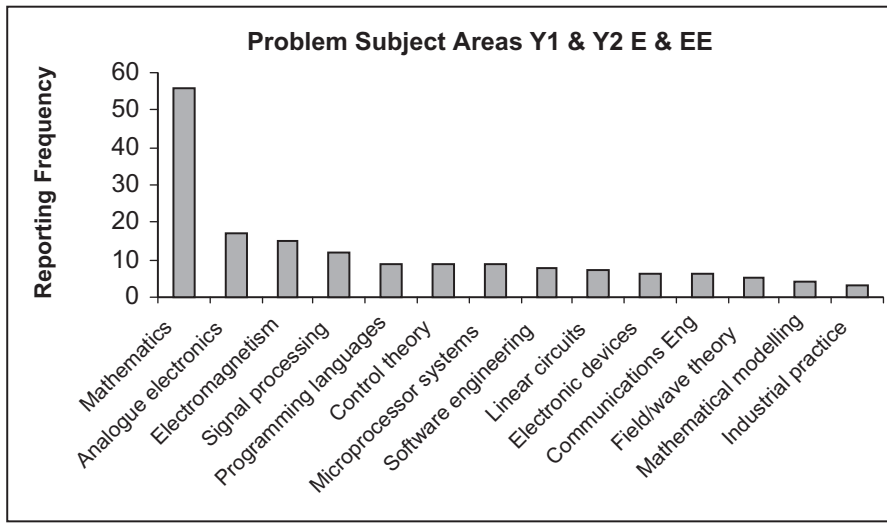

Fig. 5 *A summary of the problematic subjects notified vs reporting frequency.*

TABLE 1 *Frequency of 'active' responses to minority pastoral care issues*

Minority issues	Reporting frequency
Mature student issues	55%
Disabled student issues	33%
Gender issues	17%
Ethnicity issues	40%

project for further consultation and dissemination. Although several institutions showed an enlightened and pro-active response, the general impression was of passivity toward minority-related issues. This may be attributable to the fact that minorities, especially women, have traditionally had low participation in electronic engineering.

Table 1 illustrates the frequency of active awareness and operational response to minority issues in the sample of 42 institutions returning data. Space precludes detailed discussion of strategies. The relatively low frequency of reporting indicates there is potential for either increasing recruitment among minorities and/or increasing sensitivity toward the special pastoral care issues which affect minorities. Note that we are **not** stating that certain institutions nave no *policy* toward minority groups – merely that there appears to be potential to improve engagement with their specific pastoral care problems.

Qualitative data – counselling and strategies for non-completers

The survey also investigated the policies and procedures of institutions with respect to their handling of students wishing, or being required, to withdraw. 33% of institutions surveyed do not report *any* mechanism for tracking the fate of non-completers, and certainly the level of integration between departmental/institutional support does not appear commensurate with the problem.

Two-thirds of reporting institutions indicated that career advice was offered to non-completers, although only 52% indicated formal support systems were in place. Some respondents stated that non-completers had a poor attendance record – a clear case for early monitoring, intervention and tracking of absentees.

Qualitative data – strategies tried to enhance progression

The breadth of progression-enhancing strategies which were reported in the survey was impressive, indicating the extent to which the academic community has applied itself to the issue. Space restricts us here to a listing of the reported strategies, and it should be noted that there was multiple reporting of similar strategies, though it is felt there is no particular merit in recording the frequency of these. The details of the reported strategies are the subject of future research, development and dissemination for the PROGRESS project.

Listing of strategic response to progression problems, by category

Pre-course

- Strict admissions policy to filter out likely failures
- Institutional-level weak student screening

Skills development

- Study skills modules
- Personal skills and CPD awareness
- Essays for overseas students to enhance comprehension

Pastoral care

- Personal development tutors
- Combination of academic and pastoral care
- Counselling after a few weeks
- Diagnostic interviews on commencement

Programme modifications

- Attuning programme content to labour market
- Widening range of (technology) programmes to enhance motivation
- Industry sponsoring of equipment
- Employability-oriented modules

- Harmonisation of module contents
- Stratifying learning outcomes
- MEng only courses (industry driven)

Attendance monitoring

- Monitoring of students several times per semester
- Weekly review log of learning progress
- Automated attendance monitoring, notification, chasing

Tuition

- Compulsory tutorials
- Web-based tutorial response system

Teaching innovations

- Move from exams to project-based learning
- Early exposure to hands-on design to enhance motivation
- Peer-assisted learning/collaboration
- Problem-based learning
- Theory and practice taught in same location (technology centres)
- Open-access laboratories

Maths-specific strategies

- Drop-in maths sessions (timetabled)
- Dispersal of maths into engineering content
- Reduction of formal mathematical representation of content
- Early concentration on maths and core engineering
- Diagnostic maths testing and streaming
- Distribution of maths temporally through programme
- Supplementary tutorials for problematic areas
- Maths tuition allocated double contact hours plus extra support staff
- Computer-based maths tutorials
- Diagnostic maths testing with feedback to tutor and self-help material
- Dedicated engineer-as-maths-tutor with web support resources

Assessment strategies

- Supplementary vacation work to boost marks
- Mini-exams (contributory) during year
- Use of up to 30% coursework assessment
- Weekly progress tests
- Mid-session diagnostic tests
- Capped re-sits
- ‘remedial exams’

Feedback and quality improvement

- Student feedback to course design team
- Subject assessment panels – staff development and awareness
- Student-staff liaison committee input to course improvements

Organisational structuring

- Combined studies departmental structure – helps transfer

Conclusions

The survey has provided the PROGRESS project with some useful insights, especially in respect of the extreme variability in attrition rates under similar resource conditions across different institutions. This implies that the basic tenet of the project, namely that the dissemination of appropriate practices in teaching and learning and pastoral care can be beneficial, even under conditions of scarce resources, is sound.

Further, there is evidently a great deal of expertise and innovation in the UK which is already having significant impact in respect of progression problems.

This gives us confidence that the later stages of the project, which involve the preparation of in-depth case studies and evaluations of progression strategies with selected partner institutions, hold real promise, and that the subsequent dissemination of this material will give colleagues an opportunity to investigate such strategies for themselves.

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