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TeStED Project – Transitioning without A2 level mathematics

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Abstract

The research presented is the first stage of a project to support students entering STEM degrees. The study aims to investigate and address the mathematical difficulties that many students present transitioning to undergraduate Engineering courses. To this end data were collected to identify how age, gender, mathematical background, and preferred learning styles relate to outcomes on a mathematics diagnostic test. Both quantitative and qualitative methods of analysis were used to analyse the data. Our findings complement findings from previous research. We compared students with BTEC, GCSE and A/AS level qualifications, and related qualifications to study habits.

Introduction and background

In the UK, Advanced levels or A-levels were the traditional entry route for students to university degrees, usually taken over a two-year period from the ages of 16 to 18. However, universities have increased the number of admissions of students presenting alternative qualifications such as BTEC National diplomas to a variety of courses, including engineering degree programmes. This has presented challenges for university teaching and support structures. These structures, which range from pre-university short courses to staffed university mathematics support centres, are now common at many UK universities and provide a system of support for these and indeed all students who may struggle with the mathematical content of their course.

Looking particularly at alternative qualifications, Lawson (1995) found that there was little difference between students' overall end-of-year performance when presenting a BTEC or when presenting a failed A-level qualification (i.e. at grade N or U) upon entry. In addition, algebra skills, in particular, were found to be weak for all students. We wanted to re-investigate and refine the results on test performance and qualification in our current study, adding consideration of self-reported study habits and the effects of dyslexia and maths anxiety. We defined study habits in terms of resources used in preparation for assessments. This was in students' own time. Dyslexia relates to difficulties with phonological processing, working memory, processing speed and the automatic development of skills that may not match up to an individual's other cognitive abilities (see BDA, 2007). Mathematical anxiety is defined in terms of feelings of tension, or even dread, that results in an inability to manipulate numbers or solve mathematical problems (see Richardson and Suinn, 1972).

In this study we take a fresh look at diagnostic test results, and their relationship to study habits and students' previous mathematical experiences at school or college level. Our focus is to understand and find ways to help engineering students. In doing so we also seek to enable the dyslexic and/or maths anxious student. In the first stage of our research we aim to answer the following research questions:

1. What factors influence a student's choice of post-16 qualification in the UK?

2. Can we observe any trends in study habits? If so, how do these relate to prior qualifications and to diagnostic test performance?
3. What factors influence a student's performance on the algebra component of the diagnostic test?

Method of Investigation

To address our research aims the research team, consisting of a mathematician and two mathematics educators, collected data from (a) a diagnostic test that students took upon entry to the university and (b) a questionnaire about students' mathematical background and study habits. These formed the basis of the analysis of the first stage of the study. Additional data from (c) a screening test for dyslexia and (d) a questionnaire about mathematical anxiety is currently being collected. The final stage of the project will be the development and testing of a learning resource. We report here on the results of the quantitative analysis of the first stage of the study.

(a) The diagnostic test is a formative test taken by all engineering students in the first week of arriving at our university. The test covers number, algebra, and calculus.

(b) The questionnaire was handed out in the first two weeks of the semester as students arrived for their lectures. It was aimed at obtaining background data in relation to students' pre-university study, namely qualifications and study habits.

The research participants were all students enrolled for an engineering degree and in their first year of study. Three different cohorts of students took part in the study: material engineers, electronic, electrical and system engineers, and chemical engineers. 349 students completed the diagnostic test but not all completed the questionnaire. Subsets of the students were selected for analysis of each question to maximise sample size while controlling the possible biases caused by missing data.

Quantitative data from the diagnostic test and questionnaire were coded and entered into R for statistical analyses which we report in the next section.

Analyses of quantitative data

The analysis aimed to characterise the research participants in terms of their age, gender, qualification obtained, whether enjoyment of mathematics was a factor in deciding to continue with further study of mathematics, and whether the student had been encouraged to do so. In terms of demographics, there were 43 female participants and 226 male participants. The vast majority of students was aged 18-19 (235 participants), 26 students were aged 20-22 and 8 were aged 23 and over. Most students presented with A-levels at grades A and B in mathematics.

Factors that influenced a student's choice of post-16 qualification

We investigated which post-16 study route of mathematics among those available in the UK[6] was chosen by students who had entered university to pursue an Engineering degree. We

[6]In the UK students aged 16 years complete their compulsory education with the General Certificate of Secondary Education (GCSE) which includes grades for several subjects including mathematics. Continuing into

distinguished between two types of qualification: the more academic qualification of A/AS levels (taken by 215 of the research participants), and the more vocational qualification of BTEC/MWD which also included GCSE qualifications when these were the highest qualification that the student held (taken by 34 participants).

Using regression analysis, we found that gender was not a significant predictor. But age, enjoyment of mathematics and encouragement were all significant with p-values p=0.003 for the age group 20-22 (Age2), p=0.054 for those aged 23 and over (Age3), p=0.038 for enjoyment of mathematics (EnjoyY) and p= 0.001 for having been encouraged (EncouragedY). Removing the variable gender we obtained a regression model of the form

$$\text{logit}(L) = -0.46 + 1.6 *(\text{Age2}+\text{Age3}) - 1.2*\text{EnjoyY} - 1.4*\text{EncouragedY} \qquad (1)$$

The regression equation shows that age was most strongly related to a student's choice of post-16 qualification with older students less likely to have an A/AS level qualification. Students who enjoyed the subject were more likely to take A/AS levels as were those who had been encouraged. We must be careful interpreting this, as enjoyment and being encouraged could be associated with performance at GCSE. This information was not provided by participants unless it was their highest qualification. For our study these results are important as a baseline for subsequent analyses of data from the stage two screenings and testing.

Trends in study habits and relationship to qualification and test performance

The questionnaire was aimed at eliciting students' responses in relation to study habits. Since the questionnaire was administered in the first two weeks of the university degree course, students' responses were taken to represents their (self-reported) study habits at school or college level, and not at university level. Statements were formulated with Likert scales and focussed on the use of printed and online resources as well as 'in-person' help, e.g. from peers or family. We obtained summary data about resource use and identified three distinct clusters in terms of study habits expressed.

The resource reported as *most frequently used in preparation for a mathematics assessment* was past exam papers. Over half the students reported that they used them every time that they studied for a mathematics assessment. The second most frequently used resource was printed notes (teacher's notes or own notes) followed by mathematics textbooks. Almost all students reported getting help from a friend. When considering *online* resources, in particular, we found that online videos were used most often, followed by 'other online written' resources (not including online textbooks). It is worth noting that the use of *printed* resources (such as past exam papers) considerably outweighed help from either online resources or help provided by another person.
We next explored *differences in students' study habits* using exploratory cluster analysis. We extracted three clusters of statistically different study habits as shown in the dendogram in Figure 1 ($p<0.001$). This represents the clustering of the students in terms of similarity of reported study habits, with the three large coloured areas representing the main three clusters. Participants who did not have A/AS levels are represented by the cyan labels under the dendogram, whereas students with A/AS levels are represented by the purple labels.

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a Sixth Form or College post-16, students can take Advanced levels (A- and AS-levels) or, alternatively, vocational or technical qualifications such as BTEC (Business and Technology Education Council) or MWD (an Engineering certification, 'Measurement while Drilling').

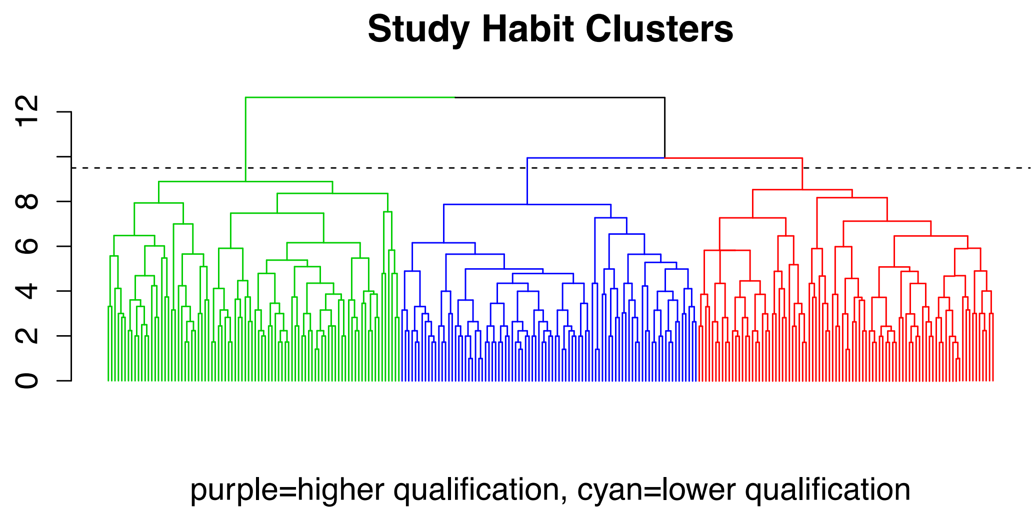

Figure 1: Students' study habits

There were highly significant differences among the clusters in their use of printed resources and online resources with both p-values less than 10^{-16}. There was no significant difference in students' use of 'in-person' help (p-value of 0.1127).

The clusters can be characterised as follows. The green cluster represents the highest users of all types of resources. The red cluster used fewer resources altogether when compared with the other two clusters. The green and blue clusters used similar levels of 'in-person' help and printed resources, but the green cluster used more online resources. We can note from Figure 1 that this is the cluster containing the largest proportion of students without A/AS qualifications.

We also compared and analysed how *study habit clusters related to performance on the algebra part of the diagnostic test*. Using ANOVA, we found that when we controlled for the qualification, study habit cluster was not a significant predictor for performance, with p-value 0.24. This suggests that being successful or not in obtaining a high algebra test score did not relate to particular study habits. It indicated a preferred style of studying but this was not a predictor for algebra diagnostic test performance.

Trends in diagnostic test performance and prior qualification

This part of the analysis was aimed at characterising research participants in terms of their performance on the algebra part of the diagnostic test. To do this we coded for participants' A/AS-level qualification in terms of grade obtained as well as for BTEC and GCSE qualification (GrQualN).

The algebra part of the diagnostic test was marked out of a total of 21 marks, with a mean of 14.58 and standard deviation 4.98.

Using standard regression analysis we obtained the regression equation

$$y = 23.22 - GrQualN*(1.59 + 0.35*GenderM - 0.45*Age1 + 0.05*Print + 0.01*Help +0.01*Online) \quad (2)$$

This shows that gender, age (where Age1 refers to the 18-19 age group), qualification with grade ('GrQualN') and use of resources which included printed and online resources ('Print' and 'Online' respectively) as well as in-person help ('Help') were all significant predictors of test scores in algebra.

When we considered test performance and qualification for different age groups (as shown in Figure 2) we found that older students tended to do better on the algebra test than younger students with equivalent qualifications.

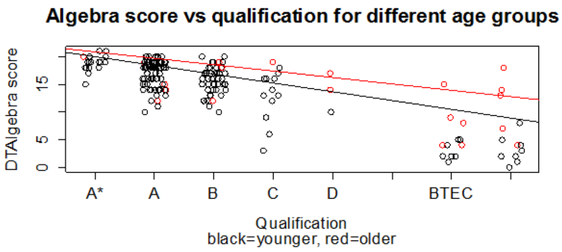

Figure 2: Test score, qualification and age group

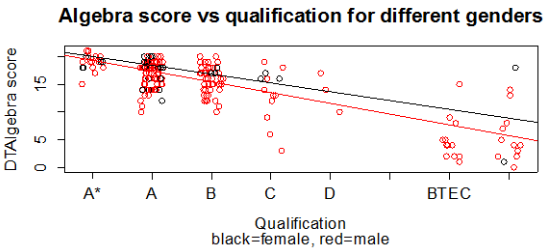

Figure 3: Test score, qualification and gender

When we considered test performance and qualification by gender (Figure 3) we found that female students tended to do better on the algebra test than male students with equivalent qualifications. Female students mostly presented A- and AS levels; there were no female students with a BTEC qualification, for example.

The regression equation (2) shows that resource use was significant, but the effect size was very small, less than 0.5 points mean difference in overall test scores.

We can see a substantial drop in algebra performance across the qualification levels with students presenting a BTEC or GCSE as highest qualification performing worse than students presenting an A-level at grade D.

Discussion of results

At this stage of our project we have results that warrant further discussion. We found that students with a BTEC qualification performed worse on the algebra diagnostic test than students with an A-level grade D, which confirms findings from previous research (Lawson, 1995). Thus after twenty years not much has changed in this position. Furthermore, detailed evidence in Gill (2016) points to a BTEC qualification as not equivalent to A-levels in terms of UCAS tariff. Suggestions are made that the current BTEC tariff of 360 points be made equivalent to an A-level tariff of 190-200. A re-evaluation of the BTEC qualification seems appropriate, as suggested by Gill (2016). In addition, students may be advised to enter for A-level mathematics since a grade D is a better predictor of performance and preparation for study than a BTEC qualification.

We also found that enjoyment of mathematics and encouragement were significant factors in the take-up of A-level mathematics. Age, too, was an indicator of choice of qualification. From this we concluded that students taking lower qualifications delayed going to university later in life.

We found three clusters of resource use. Within these clusters we found that resource use by A-level students was 'light' and based mainly on printed formats, while students with BTEC or similar qualification accessed online resources more, and resources in general more extensively than any other group. This could be explained by the difference in style and demand of teaching and learning at schools and colleges.

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Acknowledgements

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