Technological studies, physics and university entrance to engineering courses

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Abstract
This paper investigates the reasons why, in Scotland, Higher Technological Studies is failing to emerge as a credible entrance qualification to engineering courses within higher education, when compared with the success of the more traditional subject, Higher Physics.

The paper examines the wider issues on the position of Technological Studies within the educational establishment. Recent figures for the Engineering Faculty at a Scottish university show that since 1993, 86% of entrants to the faculty have Higher Physics as an entrance qualification as against 14% with Higher Technological Studies. The subsequent progress of these students is then analysed with respect to their entrance qualifications.

It then explores school pupil and parent perceptions of, and attitudes towards subject choice, in order to develop an understanding of pupils' choice of subjects at secondary school level and their career aspirations.

Should Technological Studies be viewed within a vocational subject framework?
What are the implications for future strategy in promoting Technological Studies?

Introduction

This paper will discuss some of the initial findings of a statistical research project which is currently in progress. The emergence of Higher Technological Studies in secondary school education in Scotland has gone largely unnoticed by many parents, further education and higher education institutions. When compared with Higher Physics as an option choice for further or higher educational courses, Physics still dominates in terms of entrance to engineering (Figure 1).

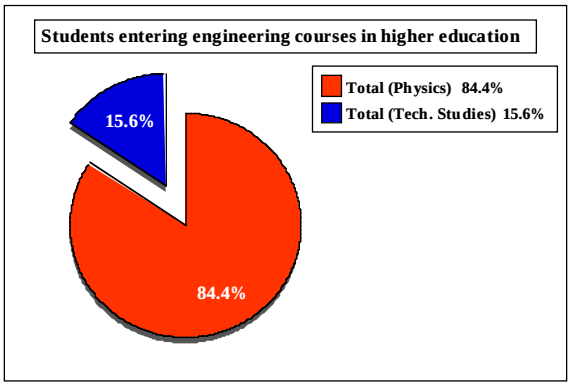

Figure 1

The lack of status afforded Higher Technological Studies as an entrance qualification to further and higher education is largely based on historical prejudice and ignorance of the Technological Studies curriculum.

> "..... although the University of Glasgow does not need Higher Physics for entry to engineering courses, it is strongly preferred for such courses here and some other universities require it for entry to engineering courses. (Schools and Colleges Liaison Service, The University of Glasgow, 1997: 3)."

The historical status of 'Technical' education and its division from the sciences has set in place two cultures within one educational system. This has predefined subject choice according to academic ability along traditional curricular lines (Mc Culloch, et al., 1985).

Background

Guidelines for balance in the curriculum offered to headteachers in secondary education (SCCC, 1989) have widely

	% Decline in Pupil Numbers from 1995 to 1997
Physics (Standard Grade)	6.3%
Tech. Studies (Standard Grade)	18.1%
Physics (Higher Grade)	3.5%
Tech. Studies (Higher Grade)	5.3%
Total Pupils in Secondary Education	1%

Figure 2

promoted the development of 'technological activities and applications' as being very important in offering a broad curriculum to all pupils. These were issued in response to the Munn report of 1977.

Since the introduction of Higher Technological Studies to the Scottish curriculum in 1988 and its accreditation as a suitable entrance qualification to related courses within higher education, no coherent program of promotion has been undertaken for the new Higher. Indeed, there are current indications that Higher Technological Studies is in decline (Figure 2).

More alarming are the current figures for Higher Technological Studies presentations in 1998, which show a full 6% decline on the previous year.

When compared with the three traditional science disciplines of Physics, Chemistry and Biology which are afforded greater status within the S3/S4 curriculum (160 hrs, minimum over 2 years - SCCC, 1989), the Technological Studies curriculum (80 hrs minimum over 2 years - SCCC, 1989) struggles to maintain its position within secondary education. This is highlighted most markedly in East Renfrewshire, the best performing teaching authority in Scotland (according to Scottish Office league tables), where only one of seven secondary schools in the region offers Higher Technological Studies, and only 8 candidates were presented in 1997 from a total pupil population of 6758. It has been viewed as subordinate to Physics and evolving largely through reform of the science curriculum rather than individual reform (Woolnough, 1975).

This, coupled with a lack of in-service support for staff at its inception, has led to a decline in pupil numbers in some areas which in turn makes the viability of the subject less sustainable.

There may be a number of reasons for the lack of uptake for Technological Studies in Scotland:

- ignorance of subject curriculum
- the traditional position of Physics within engineering courses at Further Education and Higher Education level
- pupil advice from guidance departments

The diversity of the Higher Technological Studies curriculum and its academic nature, offers students the opportunity to gain knowledge in a number of discrete areas of engineering. In particular, the trend in further and higher education towards multidisciplinary engineering courses such as Mechatronics in many ways mirror the curriculum and philosophy of the Higher.
The debate as to whether Higher Technological Studies should direct itself towards industrial training as opposed to Further Education or Higher Education (Urquhart, 1996) is important but should not deflect attention from the academic rigour of the subject and its suitability to engineering courses.

Evidence would suggest that in some quarters of higher education, Higher Technological Studies is regarded as supplementary to, as against an alternative to Higher Physics. The role of Higher Technological Studies as a pre-vocational subject may be disputed from the viewpoint of both content and nature of the curriculum. It could be argued that the

Region	No. of candidates per 100,000 population
West	13
East	25
Central	27
Highlands and Islands	34

Figure 3

Technological Studies curriculum is more substantially directed towards many engineering courses in further and higher education due to their 'applied' nature.

The language of technology

The reinvention of Technological Studies and the choice of name sought to distinguish the new subject from its previous designation, 'Engineering Science', has made little impact in attracting new and academic pupils to this challenging and dynamic subject. The use of the word 'technological' itself may be argued as being counter-productive in that it conveys little in terms of specific course content and is difficult to conceptualise within the wider usage of the word.

Higher technological studies in Scotland

In seeking to investigate the nature of Higher Technological Studies' failure to gain a foothold at Higher educational level it is important to understand some of the geographical implications. The disparity of candidate numbers between the west of Scotland and other areas has been linked (through discussion with subject staff) to a fragmented approach to in-service training offered at the inception of the new Higher. This varied radically across the individual teaching authorities.

The variation of pupil uptake by region is worrying when we consider the population distribution in Scotland and its concentration around the two largest cities, Glasgow in the west and Edinburgh in the east. Most markedly the west of Scotland can be seen to present far fewer candidates per head of population than the other three designated regions (Figure 3).

Justification for the running of Higher Technological Studies also becomes difficult when candidates for presentation in schools are seen to be so low (Figure 4).

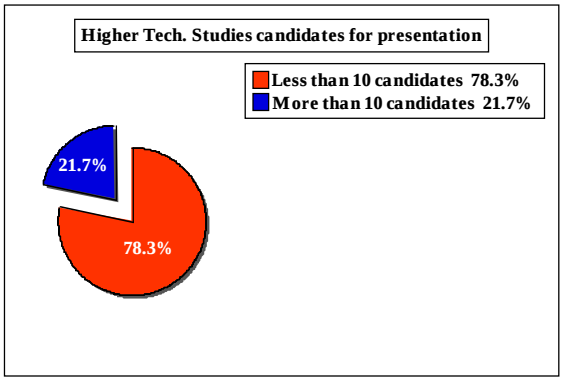

Figure 4

Higher technological studies compared with higher physics

When we consider the curricula on offer for both Highers it becomes apparent that whilst the Physics option deals more fundamentally with laws and their derivation, Higher Technological Studies offers elements of the curriculum which are inherent to many discrete Further Education and Higher Education engineering courses (Figure 5).

An example of this would be the structures element of the Technological Studies course which has little if any overlap with other subjects and which is directly applicable to Civil Engineering courses within further and higher education.

Engineering students in Scottish Universities

With Higher Technological Studies now regarded as an alternative entrance qualification to Higher Physics in most engineering courses at Scottish Universities, the proportion of intake given to each subject displays a startling disparity.

Higher Physics - Course Content	HigherTechnological Studies - Course Content
Mechanics and Properties of Matter Electricity and Electronics Radiation and Matter	Industrial Study Energy Utilisation Programmable Systems Electronic Systems Structures and Materials

Figure 5

This was highlighted in considering entrants to two departments within the Engineering Faculty of a Scottish university (Figures 6 & 7). The numbers for Higher Technological Studies in each department, clearly indicate that the subject is viewed from a pre-vocational, non-academic standpoint, subordinate to Higher Physics. This is a view which is further validated by pupils perceptions of the two subjects.

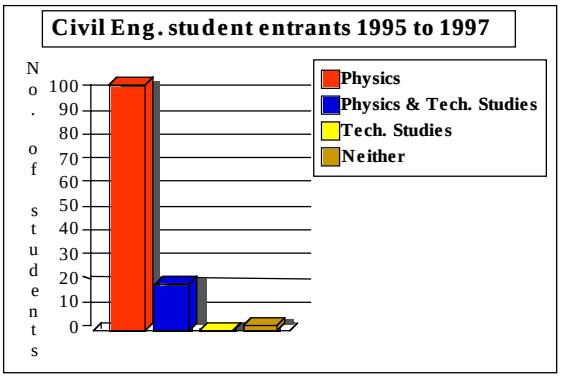

Figure 6

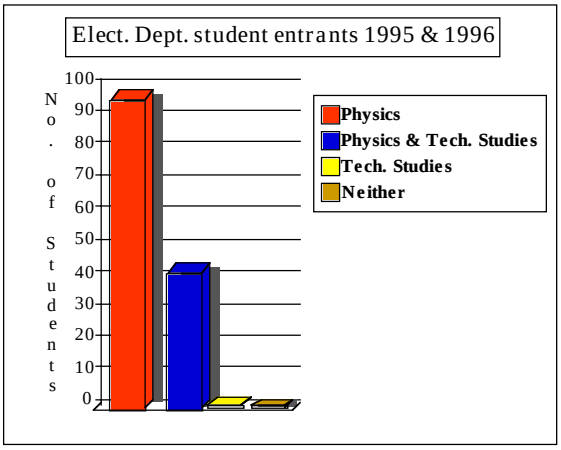

Figure 7

First year students in Department of Electronics and Electrical Engineering

In order to investigate any difference between first year student achievement and the kind of Highers taken, a study was carried out with a group of first year electronic and electrical engineering students. Firstly the number of students entering the department with either of the Highers or both was investigated. The fact that no students entered the department over the two year test period with Higher Technological Studies as an alternative to Higher Physics could be seen as significant in itself considering the fact that entrance requirements indicate clearly that Technological Studies or Physics are acceptable.

A sample group for analysis was selected which consisted of 28 students with Higher Physics as an entrance qualification. These students were matched with 28 similar students with Higher Physics as well as Higher Technological Studies. Students were matched on the basis of their Higher Physics result as this was common to the entire sample.

The resulting data was tested against the Null Hypothesis (H_0) :

> "There is no difference between student performance with Higher Physics against Higher Physics and Technological Studies."

The sample was analysed on the basis of first year examination results covering four subjects :

- Electronic and Electrical Engineering
- Engineering Physics
- Mathematics
- Computing Studies

Subject	Mean Score (Physics)	Mean Score (Physics & Tech. Studies)
Electronic and Electrical Eng. Engineering Physics Mathematics Computing Science	9.39 9.25 8.61 7.93	9.18 9.11 7.36 6.93

Figure 8

Using a statistical software package (SPSS), the first year examination results of the students were analysed firstly on the basis of overall performance across the four subjects, then on performance in each of the four individual subjects. Since the data for analysis was categorical in nature and consisted of matched pairs of students, a Wilcoxon Matched Pairs Signed-Ranks Test was chosen as the tool with which to test the Null Hypothesis. In terms of statistical significance the tests showed no statistical significance based on a 95% confidence interval. It was however noted that in each of the four subjects, the group with Higher Physics achieved a marginally higher mean score when compared to the group with both Highers (Figure 8).

Pupils' perceptions

As a means of further investigating the position of Technological Studies within the wider curriculum and more specifically as an entrance qualification for university, secondary pupils' perceptions were investigated through two questionnaires. The questionnaires were identical in content except where questions related directly to the particular subject.

The use of the same questionnaire for pupils from each subject was intended to highlight any significant differences in perceptions and attitudes between the two groups. The sample group consisted of 20 Physics and 11 Technological Studies pupils in 3rd year.

A series of open questions were chosen in order to gain more detailed responses from the pupils. Since the aim of the questionnaires was to test perceptions of the two subjects with respect to university entrance, the sample was chosen from schools with high recorded levels of academic achievement. The key questions for analysis within the questionnaires were :

Why did you decide to take Physics/ Tech.Studies? (Figure 9)
The pupil responses here give a picture of the aspirations of pupils in both subjects and their educational strategies. It can be seen that the Physics pupils view the subject predominantly in terms of future career as against the Technological Studies pupils who are less focused in their reasoning.

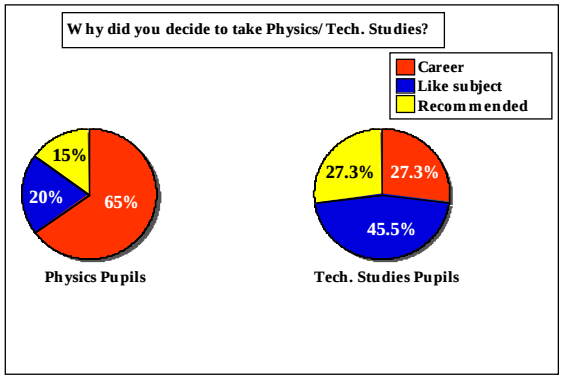

Figure 9

Do you hope to go to university when you leave school? (Figure 10)
Again we can see that the Physics pupils are more certain of their intentions with regards to entering university. This would indicate that Physics is viewed more widely as a precursory qualification for entrance to university than Technological Studies.

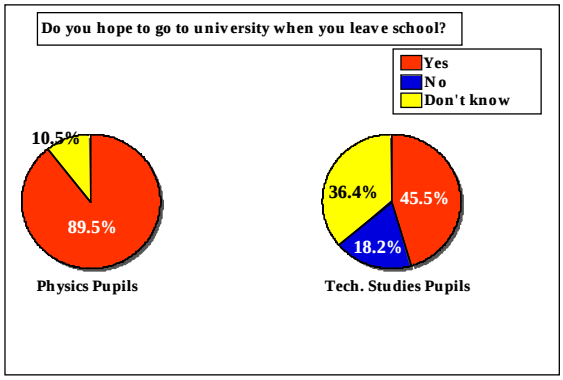

Figure 10

Which subjects are most important for engineers? (Figure 11)
This would indicate that the perceptions of pupils are polarised according to the subject which they take. The difficulty here is in further defining 'engineering' since the term has multifarious uses. Are both sets of pupils using the same definition?

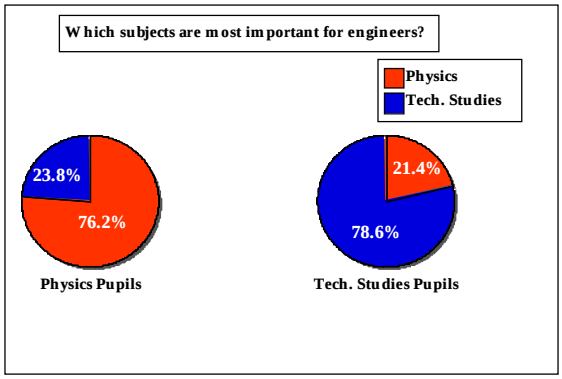

Figure 11

Name some occupations which Physics/Tech. Studies is good for (Figure 12)
Here we have perhaps the clearest indication that pupils perceptions are very different for each subject. It can be seen that in terms of Physics, the general trend is towards professional occupations, with many requiring some form of further or higher education. The response for the Technological Studies group was more definitely directed towards apprenticeship based occupations. The diversity of occupations received from the Physics pupils would also imply that these pupils are again more focused in their actual career choice and highlights the flexibility which Physics offers pupils who wish to enter further or higher education.

There was an element of overlap apparent in pupils' responses between the common areas of both Technological Studies and Physics, which is mirrored to some extent in other studies (Griffiths & Parsons Heath, 1996). Many pupils who had knowledge of both subjects found it difficult to distinguish between areas of both subjects when asked how they would compare the two.

Parents' perceptions

The influence of parents on pupils' choice of subjects in secondary school, as well as parental knowledge of individual curricular areas may play a large part in the option choices which are selected. A sample of 24 parents were chosen to test attitudes and perceptions of their children's' subject choices and more specifically with regards to

Occupations which Physics is good for.	Occupations which Tech. Studies is good for.
teacher, engineer, music, pilot, space, electronics, aerospace, car design, astronomy, nuclear industry, dentist, computers, radiography, biochemistry, medicine, research, forensics, architecture, technician, mechanic, electrician, plumber	teacher, engineer, aerospace, electrician, mechanic

Figure 12

university entrance and engineering careers. A Likert type scale was utilised in this questionnaire for most questions.

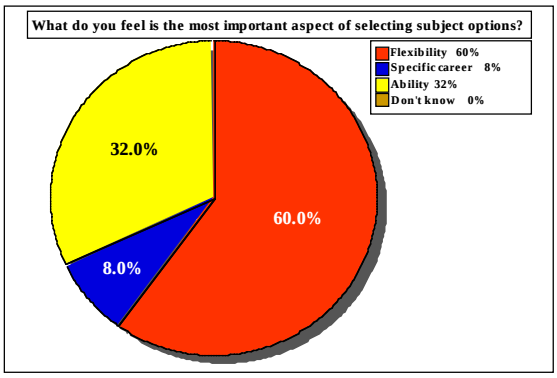

Figure 13

The key requirement of flexibility within the curriculum choice of pupils highlights the benefits of opting for Physics as this could be perceived to offer more flexibility in ultimate career choice. This would be particularly applicable for those pupils who wish to enter further or higher education, but have no specific course in mind whilst at secondary school (Figure 13).

Future strategy

In order to establish a platform from which Higher Technological Studies can develop, a number of key areas require consideration:

1 There may be a case for the development of promotional strategies to highlight the curriculum on offer within the Higher Technological Studies course and its relevance to engineering courses at further and higher educational level. The evidence of students performing better with Higher Physics than those with both Highers (Figure 8), may be the result of a lack of recognition given to Higher Technological Studies by the most able pupils and the Further Education and Higher Education institutions themselves.

2 Recent trends towards 'technology across the curriculum' supported within the SCCC's 'Statement of Position', may paradoxically undermine Technological Studies, as local teaching authorities see potential for rationalisation. It is therefore important to fully define and package the subject as individually valid and discrete from other areas of the wider curriculum.

3 There is also room for the argument that the Technological Studies curriculum should ultimately integrate with the wider Science curriculum (Layton, 1993) which is now more contextual and 'applied' in nature. This would ensure that important aspects of the Technological Studies curriculum reach a wider audience.

4 The effects of gender and social inequality (Croxford, 1994), whilst not dealt with specifically in this paper must also be considered when the child's broader curriculum is planned. Care must be taken by guidance staff to avoid stereotyping of pupils along gender and socio-economic lines. The viewpoint that some subjects provide primarily pre-vocational training and offer little academic benefit may also serve to mislead and prejudice pupil choices when selecting subjects such as Technological Studies.

5 The current preoccupation with 'technology' in education has led to a blurred abstraction of the term through its multiplicity of uses. It brings into question the use of Technological Studies as a name for the subject as it can easily be lost within the wider terminology.

Conclusion

The intention of this paper is to provide a broad overview of some of the problems faced in promoting a subject in secondary schools which is largely regarded as vocational and non-academic. Much of the misinterpretation and stereotyping of the Technological Studies curriculum is historic in nature and is common to many Technology curricula. The implications for the future of the subject, may hinge on further reform through Higher Still within the Scottish system, which may give further opportunity for the reinvention of the subject.

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