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A Look At Vocational And Academic Student Backgrounds In Ability To Solve Practical Problems

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A LOOK AT VOCATIONAL AND ACADEMIC STUDENT BACKGROUNDS IN ABILITY TO SOLVE PRACTICAL PROBLEMS

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ABSTRACT

While most students in the UK will enter engineering degrees with traditional academic qualifications, a significant proportion will come from backgrounds which use vocational based qualifications to gain entry to degree level study. Indicators show that students from lower socio-economic backgrounds are more likely to be among those using vocational qualifications to gain entry to University and may not progress as well. This is often linked to difficulties in traditional academic elements of the degree such as mathematics where both the content and learning approaches are much less familiar to students with a vocational background. These academic skills are not the only skillset needed of a graduate engineer and to look at ability in practical problem solving a trial was devised.

Students in their first year of a range of engineering degree programmes were recruited from a number of disciplines including those on mechanical, electrical and chemical engineering degrees and having entered those degrees from a range of educational backgrounds.

Students were paired up to work on a series of short problem solving exercises designed to require an element of logical and creative thought of the type needed in

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engineering problem solving but were such that no specific technical knowledge was needed. Work was videoed and then encoded to help with analysis.

The work, while from a small sample size, appeared to illustrate that students on engineering programmes want to solve problems and capability appeared to be independent of educational background suggesting this skill may be lost to society if engineering students from vocational backgrounds drop out early due to struggles with more academic topics.

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1 INTRODUCTION

1.1 Pre-university Study Routes and Outcomes

While many countries will have a “normal” entry route for entry onto university level degree programmes, there are often quite significant alternative routes, particularly for those types of degree, including engineering, which lead to a vocational career path.

Within the English and Welsh context, entry to university is typically based around student performance on high school leaving qualifications known as A-levels lasting two years from when students are 16. Students will commonly take three A-levels in classic academic disciplines such as Mathematics, Physics, History etc. Each degree programme at each university will then have an entry tariff based on an appropriate mix and grade in these qualifications (eg. BBC to include grade B in Maths and a Physical Science or Technology subject).

At age 16 however students with weaker academic performance may find routes to A-levels closed and may move onto a vocational stream, though others may choose this even if qualified for the A-level option. This stream leads to an applied qualification, typically an award known as a BTEC, though this has recently replaced by the newer T-level qualification. The newer qualification features 45 days industry placement as part of the training but carries forward much of the BTEC approach and aims at a similar market [1]. A single BTEC or T-level is built around the skills needed broadly for entry into a career of further study in a vocational field, such as engineering, agriculture, construction or catering and is nominally equivalent to three A-levels. As such these qualifications are also often used as a route into a University degree or apprenticeship.

Experience has however shown that students from vocational routes have often struggled adapting to university study with higher drop-out rates and final outcomes [2-4].

1.2 Research Question

It should be stated that the reasons for the poorer performance of vocational students once on their degrees has been attributed to a range of factors. These include the students’ background – a higher proportion will come from lower socio-economic groups with less family history of high education [5,6] and the nature of the qualification – often having few exams but more coursework, leaving a study skills gap. For engineering students there are often particular issues around mathematics elements of degrees [7] however the gap between vocational and academic entry qualifications is sector wide [8-10].

Ultimately however engineering is a vocational discipline aiming to provide workable and effective solutions to technical challenges. Underpinning academic knowledge can support this but is not always the key to effective and pragmatic problem solving.

This work therefore looked at the problem solving skills of a range of students coming into University engineering degrees to help answer the question “Does pre-degree academic background influence problem solving ability?”

2 METHODOLOGY

2.1 Participants

Students were invited to take part from cohorts on the first semester of engineering degrees at an English university. These students were targeted to ensure the investigations were largely focussed on assessing the problem solving skills brought by the students into the degree from their different backgrounds rather than those developed during the degree. A modest “thank-you” shopping voucher was provided to participants in recognition of their involvement. Selection of candidates and the overall methodology went through the ethics process of Aston University (ref.1550).

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2.2 Problems Set

The problems set were mixed to explore different challenges. Some relied on logic and a process of honing in on a specific answer, others involved geometry and shape fitting with others were more open ended asking for ideas for devices or approaches to solve practical problems.

Fig 1. Still excerpt from student problem solving videos

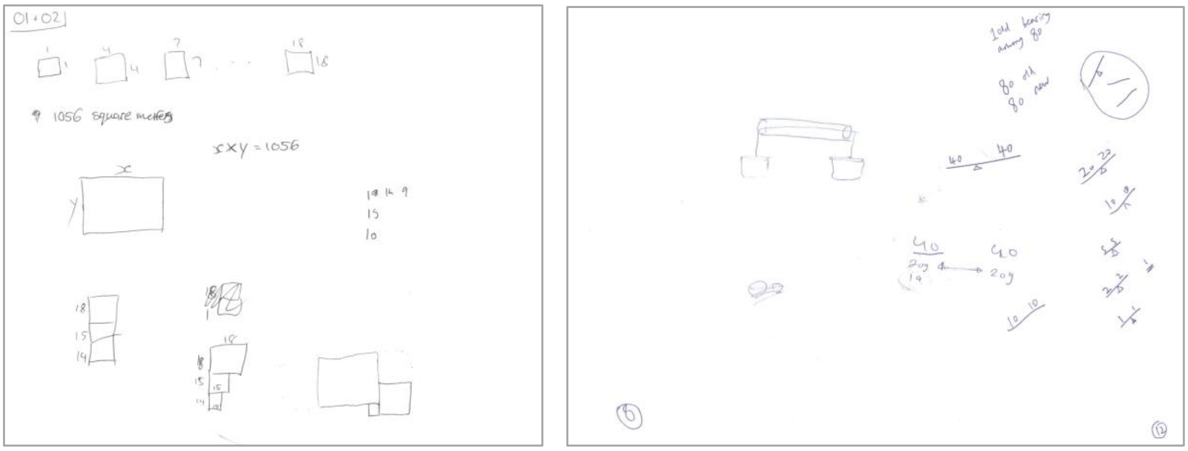


Fig 2. Student note sheets

Exemplar Trial Record Following Transcription and Coding

Date : 26.01.22
Location : L36
Problem set : Ball Bearings
Participants : 5,6

Time		Code	Tool	Notes
03:42:32				Problem set
03:42:46	00:00:14	EXP		Solution proposed (5)
03:43:19	00:00:33	QUE		Is that method slow...
03:46:05	00:02:46	ADA		Try to optimise process
03:46:20	00:00:15	PRS		Yes that's it its legit, man we're so smart, its why we do engineering bro!
03:52:00	00:05:40	PAUSE		
03:53:24	00:01:24	QUE		Realise (diricred that there is an error)
03:54:43	00:01:19	ABA		Try to think of indirect solution despite being on the right lines.
03:56:00	00:01:17			Time limited - problem abandoned.

Exemplar Trial Record Following Transcription and Coding

Date : 26.01.22
Location : LG36
Problem set : Logic You Tube
Participants : 14,16
File : C:\Users\thomsoga\Desktop\Trial Data\220126-14-16\SUNP007

Time		Code	Tool	Notes
14:34:03				Info released
14:34:36		CLR	paper	14 notes down key info "I am literally writing it !"
14:35:00		PRG	paper	16 formally writing down variables
14:37:58		TRI		Debating different ideas - could also be...
14:39:30		QUE		Questioning - trying to eliminate options ?
14:40:23		TRI		Following a semi logical path, gradually eliminating and confirming data
14:42:00		PRE		Finished ?

Fig 3 : Encoded data from student trials

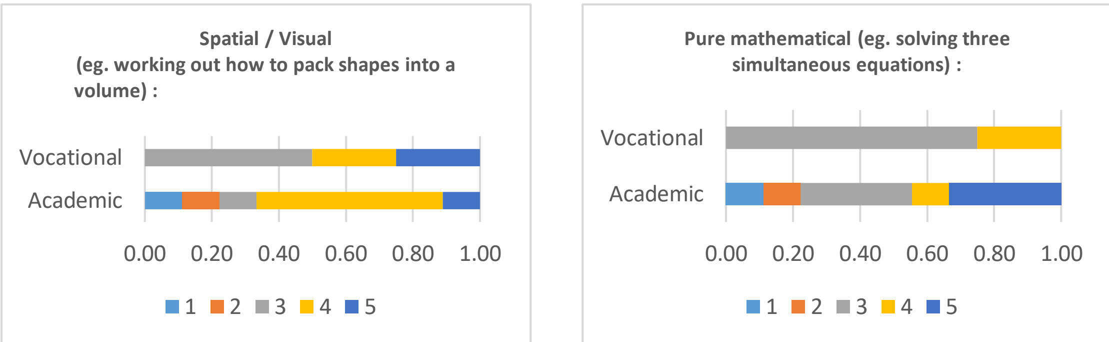
2.3 Protocol

Students were initially asked to complete a questionnaire covering some background demographics together with a self-appraisal of confidence levels and preferences in terms of problem solving. Students were paired up to carry out problem solving with the pairing designed to encourage a dialogue which would draw out the problem solving strategies and approaches. The problems set were varied but did not require specific engineering knowledge as the students were all new entrants to a degree and the focus was on solution finding approaches rather than any underpinning factual knowledge. Basic (non-calculus) maths skills were however expected. Students were allowed to use a calculator if needed and were provided with blank paper to help sketch out and communicate their thoughts. To provide a record of the work students were videoed solving the problems (Fig 1) and the sketches and written workings were retained (Fig 2). Data was then encoded for analysis and review (Fig 3).

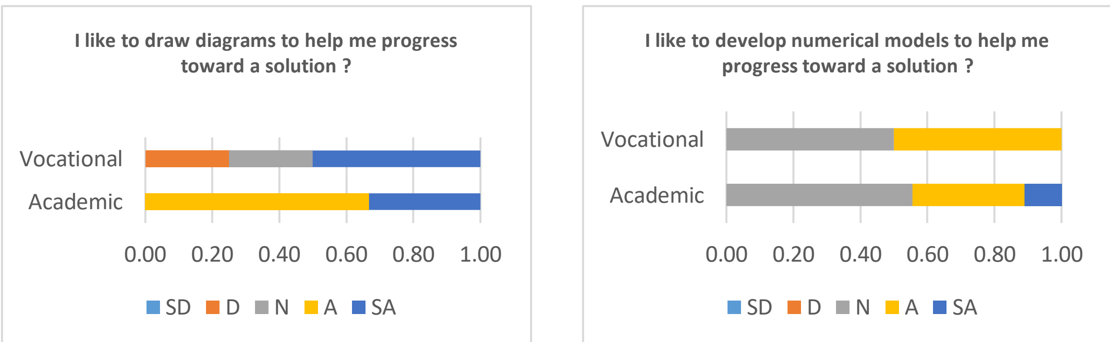
3 RESULTS AND DISCUSSIONS

3.1 Questionnaire

Students were asked a range of questions in the questionnaire related to demographics, confidence levels in solving different problem types and preferred approaches in solving problems. Figure 4 shows outputs from some of these questions.



(a) Student confidence levels for different problem types (1-low, 5-high)



(b) Student problem solving approaches (Strongly disagree (SD) > Strongly agree (SA))

Fig. 4 : Sample data from student questionnaires grouped by entry qualification type

While there are some differences in preferences and confidence levels between the students who entered via a traditional academic route and those who arrived using other qualifications, the limited numbers of participants limit the extent to which the data can be considered statistically robust.

For the practical tests, performances were relatively similar between the two groups of students.

Most students were able to complete the logic type problems in a similar manner. These problems had a set of incomplete data together with statements which, if applied logically, could complete the missing data. Most student pairings were able to complete these satisfactorily. Tables were commonly used to identify the given, resolved and missing data with a semi-systematic approach to identifying the missing results.

Similarly both groups embraced some of the more open ended challenges, such as proposing design ideas for a tool to help plant seeds precisely or another to extract small objects from childrens' ears and noses. An iterative approach was used and these new students, while early in their evolution as engineers and lacking formal training often brought in personal experience to inform the process. Iterative and sharing processes involving validations, additions and improvements were also common. Surprisingly, given the goal and the brief, the use of drawing and sketching to explain or develop ideas was far less common.

The use of physical aids to help in the problem solving was also explored via a tile fitting problem. Students were tasked with determining the size of rectangle which could be constructed from a set of square tiles (*Fig 5*). At the start of the problem the tiles were merely listed and not presented physically. It is however relatively straightforward to determine the rectangle size as the overall area of the tiles is known and only certain combinations of rectangle geometries would fit with the tiles provided. Only one student pairing however achieved this and most relied on sketching possible layouts to aid their thinking and then using the later supply of physical tiles to solve the problem (*Fig 6 & 7*). There was no notable difference in approach between those students from academic or non-academic entry routes.

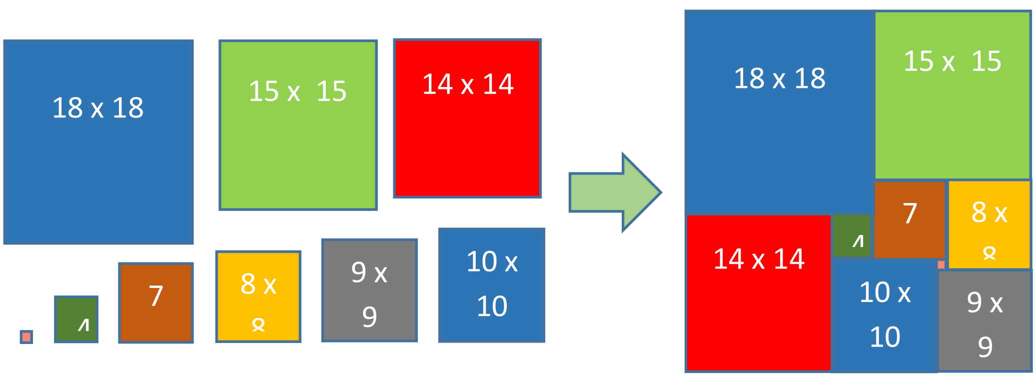


Fig 5 : Tile fitting problem (with solution)

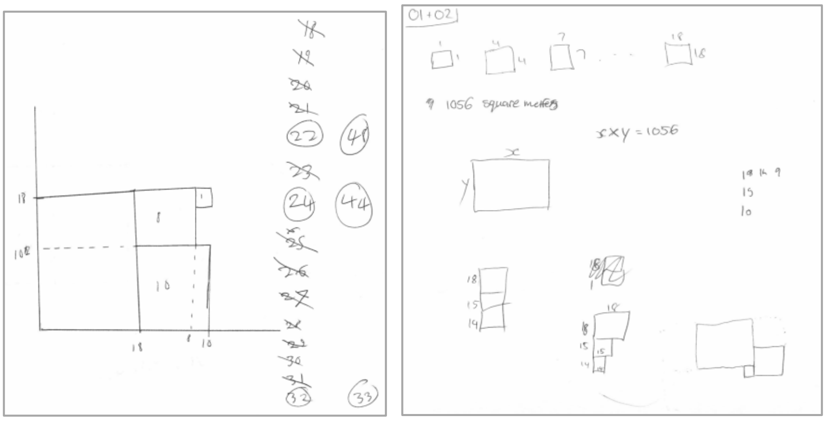


Fig 6 : Student Working Papers For Tiling Problem.

Fig 7 : students using physical paper tiles to solve the tiling problem

4 SUMMARY AND ACKNOWLEDGMENTS

4.1 Summary and future work

The work here indicated that the core problem solving ability of students appears very similar whether they entered university with a background centred on academic or vocational qualifications.

The robustness of these outcomes are not as strong as would be hoped due to the small sample sizes (n=20) and difficulty in recruiting participants. It is hoped to re-run a similar trial in future using the same protocol to bolster the underlying dataset.

None the less if we believe problem solving to be the core of professional engineering practice to lose students from vocational backgrounds with sound fundamental skills in finding solution can not be a sound long term option.

4.2 Financial support acknowledgements

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