

A TRANSITION STUDY TO SUPPORT CURRICULUM REFORM

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ABSTRACT

This paper presents details of a project to support the transition from school to university for engineering students in the UK. The initial phases have already been disseminated by the project collaborators. The background, rationale, objectives and outcomes of this latter phase of the project are presented and specific data from a web-based transition diagnostic is discussed which verifies specific learning issues amongst engineering students enrolling in their first year of study. This prompted further investigations into these specific learning issues, which produced relevant data pertinent to enhancing learning through curriculum reform with the ultimate goal of accommodating the transition from school to university, improving the learning experience and increasing retention.

KEYWORDS

Transition from school to university, web-based diagnostic tool, curriculum reform, student support.

INTRODUCTION

Over thirty years ago it was acknowledged that UK engineering students experience specific issues in their transition from school to university (Jolly & Turner, 1979), which need to be addressed early in their first year of study. The emphasis was on providing more information to the secondary schools regarding the nature of engineering careers and what university engineering courses require in terms of preparation, education and training. Psychologically speaking, it is very important to meet students' expectations for their chosen courses: the more prepared and informed they are the better (Jackson et al., 2000). The first-year experience of university students is a large research area with key issues such as transition and retention playing a major role. More recently, the Higher Education Academy in the UK funded an extensive and comprehensive review of more than 750 publications on the topic of the first-year experience covering a 40 year period (Harvey et al., 2006). Regarding transition issues, it is important for universities to actively manage student expectations rather than react to them. Therefore, for engineering courses it is important that both students and staff are well informed in advance to manage such expectations.

Since 2010, the author has been involved in a project with collaborators from engineering schools in other UK universities to help understand and manage the transition to university for their students. It is widely acknowledged that this transition from school or college to university is a critical stage in generating and maintaining student motivation and improving engagement and hence retention.

The overall aim of the work is to provide opportunity and guidance to better motivate and educate engineering students. The specific aims of the project are:

- To better understand student knowledge on entry and tailor their first-year programmes.
- To align staff perceptions to the knowledge of first-year cohorts.
- To facilitate appropriate programme development based on relevant entrance requirements.
- To provide more up-to-date information to prospective students considering engineering programmes.
- To offer a self-assessment tool to prospective students and their teachers.

The first three aims described above support the implementation of CDIO Standards 2 and 9 by acquiring pertinent information to set and achieve realistic and relevant learning outcomes (Crawley et al., 2007).

The initial phase of this transition project involved developing a diagnostic tool for assessing aspects of the knowledge and experience of incoming engineering students, under the perception that it would be extremely useful in delivering and improving first-year undergraduate engineering modules if staff could be given a reliable profile of the attributes of the incoming student cohort (Goodhew et al., 2011). Prior qualifications do not necessarily capture technical understanding, practical skills and a general understanding of the societal context in which engineering is being taught.

In subsequent phases, a concise set of web-based diagnostic and support tools were designed and developed in an attempt to clearly identify these attributes of students entering engineering programmes in the UK and support their transition into university. The project team devised a set of questions with appropriate feedback and support for incoming students, developed a web-based tool for their delivery (during the initial weeks of the academic year) and a robust data query tool for retrieval of the resultant data. At the start of the 2011 academic year this was trialled in six institutions and completed by almost 600 students. Its efficacy was evaluated, discussed and disseminated by Goodhew et al. (2013).

The methodology and specification for the questionnaire were carefully established by the project partners. The key features are:

- The questionnaire is web-based and independent to maximise transferability and usage between institutions.
- Students must be able to complete the questionnaire within one hour.
- The essential data logged per student is limited to: institution name; programme name; most recent qualification (e.g. A-level); fee status (home or overseas).
- Every question permits a “not sure” response to minimise guessing.
- The associated rubric emphasises that the questionnaire is anonymous and that it is not a “test”.
- Feedback and support is provided on completion of the questionnaire via the web-based system.
- A comprehensive data-base ensures cohort results are readily and easily accessible to relevant staff.

The questionnaire covers aspects of technical knowledge (from prior study such as maths or physics), practical awareness (of hand tools, computer use) and background knowledge (on relevant engineering topics such as the workings of a combustion engine). Due to the backgrounds of the project partners the questions were weighted towards mechanical and materials engineering.

Goodhew et al. (2011, 2013) discussed the results from the initial implementations of the project questionnaire, noting immediately that certain areas of technical knowledge specifically related to entrance qualifications were not well recalled by a significant percentage of transition students from all of the institutes surveyed; an area for further study. They also noted that future developments of the project hoped to evaluate ensuing changes planned or made at module and programme level in the deploying institutions.

It should be noted that the scope of the work described in this report was not to affect or change secondary education, but to better understand it by better understanding the skills and attributes of students enrolling on the engineering pathways of the collaborating universities. The entrance requirements for the collaborators' engineering degree courses are based on a perceived understanding of secondary level qualifications, which needs validated by such a transition questionnaire as developed in this project.

This report presents detailed information on the implementation and results of the transition project relevant to the School of Mechanical & Aerospace Engineering at QUB. Specific data gathered is presented, which helped identify more clearly the knowledge, understanding and attributes of students entering its engineering programmes in 2011 and 2012, which was a key objective of the study.

A significant outcome of this data was to identify a specific problem relating to the level of mechanics knowledge that faculty perceived students as having. As part of its curriculum reform strategy, the School had addressed the well documented issue of teaching mathematics to engineering students (McCartan et al., 2010). However, consistent findings from the transition project corroborated significant data published in the UK showing that students entering engineering courses were potentially not well prepared for the first year curriculum in mechanics, which sparked a further detailed investigation within the School (Cole & McCartan, 2013).

These findings are discussed and data presented, comparing entrance qualifications with the respective results from the transition project in 2011 and 2012, which helped highlight the problem with mechanics skills and learning, and verified that more support and curriculum reform was required.

WEB-BASED TRANSITION QUESTIONNAIRE

The web-based Transition Questionnaire was designed so that each of the forty questions belongs to one of three sub-groups:

- Knowledge - a question that tests factual knowledge, such as the properties of a material or the meaning of a technical term.
- Skills - a question that tests process knowledge, such as being able to identify the correct tool to use or considerations for an experimental setup.
- Reasoning - a question that tests ability to calculate and reason, such as understanding the analysis of a mechanical system or using specific mathematics.

Table 1. Groupings and Descriptions for the Questions in the Transition Questionnaire – colours show specific areas that were poorly answered.

Group	Question	Description
KNOWLEDGE	1	Thermo - heat metal - does hole size increase etc.
	2	Thermo - heat transfer - frying pan, sun radiator
	3	Thermo - boiling point of water at altitude
	4	Fluids - water flowing in conical pipe
	5	Physics - nuclear power
	6	Mechanics - identify vector and scalar quantities
	7	Mechanics - energy
	8	Mechanics - pulley systems
	9	Mechanics - gears
	10	Mechanics - 4 stroke engine cycle
	11	Mechanics - statics - truss
	12	Mechanics – Newton's 2 nd law
	13	Mechanics - moments - seesaw
	14	Mechanics - statics - tension, compression, shear
	15	Mechanics - CoG - aeroplane baggage effect
	16	Mechanics - units
	17	Materials - properties of steel and aluminium
	18	Materials - titanium
	19	Materials - composites
	20	Materials - identify which is metal, polymer or composite
	21	Manufacturing - production processes
	22	Manufacturing - production processes
	23	Manufacturing - production processes
	24	Manufacturing - production processes
	25	Maths - trig - id trig graphs
	26	Electrical - circuits
SKILLS	27	Mechanics - units
	28	Mechanics - scale of different objects
	29	Maths - significant figure
	30	Technology - identify different saws
	31	Technology - identify different saws
	32	Technology - identify different screw heads
	33	Professional Skills - Microsoft Office
	34	Professional Skills - Gantt Chart
REASONING	35	Maths - trig identity
	36	Maths - comprehension and percentages
	37	Maths - graphs and percentages
	38	Maths - pie charts and percentages
	39	Maths - differentiation
	40	Mechanics - statics

The questions have been split into these sub-groups to facilitate the feedback presented on completion of the questionnaire: learning is different for each group - feedback for a 'Knowledge' question would generally involve reading an article on the subject whereas for a

'Reasoning' question would involve completing practice questions. Questions can have aspects of more than one group, but the key aspect being tested has determined their classification as shown in table 1, which also includes a basic description of allocated category (mechanics, materials etc.) and content.

The Transition Questionnaire is intended to capture the attributes of a cohort of students. It is completed anonymously, within one hour and ideally scheduled in the timetable at the beginning of the first year, so that an instructor can guide and invigilate. The questionnaire instructions emphasise that it is not a test, but instead a guide and benefit for both students and faculty. To avoid any collusion, the questions are presented in a random order by the web-based system.

RESULTS FROM QUESTIONNAIRE

The web-based system logs the data from the questionnaire against the following input areas: institution name; programme/course name; most recent qualification (A-level etc.); fee status (UK/EU/Other). This provides flexibility in interrogating the data base.

What was interesting to study initially was the comparison data between participating engineering schools that ran the Transition Questionnaire. It was necessary at an early stage in the project to validate and verify the responses from these different schools to ensure that there were no unexplainable anomalies. Figures 1 and 2 provide examples of such comparisons for several of the universities (uni1, 2, 3 etc.) that participated in academic years beginning 2011 and 2012 respectively. QUB is represented in both figures.

It should be noted that all of these participating institutions were UK engineering schools with similar programmes such as mechanical, aerospace, manufacturing and product design engineering, and with the majority of entrants having A-Level qualifications. It should also be noted that the general trends illustrated in these two figures represented students from all of their programmes and were reasonably consistent across all of the participants, but that for presentation purposes only the results from four and three institutions were plotted respectively. The 2011 results plotted in figure 1 represent a total of 383 completed questionnaires. The 2012 results plotted in figure 2 represent a total of 456 completed questionnaires.

The format of the graphs allows the reader to cross-reference the list of questions in table 1, which are also summarised and displayed in the graphs in each of the three question groups: Knowledge, Skills and Reasoning.

Figures 3 and 4 present the web-based Transition Questionnaire results in 2011 and 2012 from first-year students entering the School of Mechanical & Aerospace Engineering at QUB on one of its three undergraduate programmes: Mechanical Engineering (Mech); Product Design Engineering (PDE); Aerospace Engineering (Aero).

In 2011 67% of all first-year students completed the questionnaire: Mechanical 61%; Aerospace 71%; Product Design 100%. In 2012 65% of all first-year students completed the questionnaire: Mechanical 60%; Aerospace 78%; Product Design 71%.

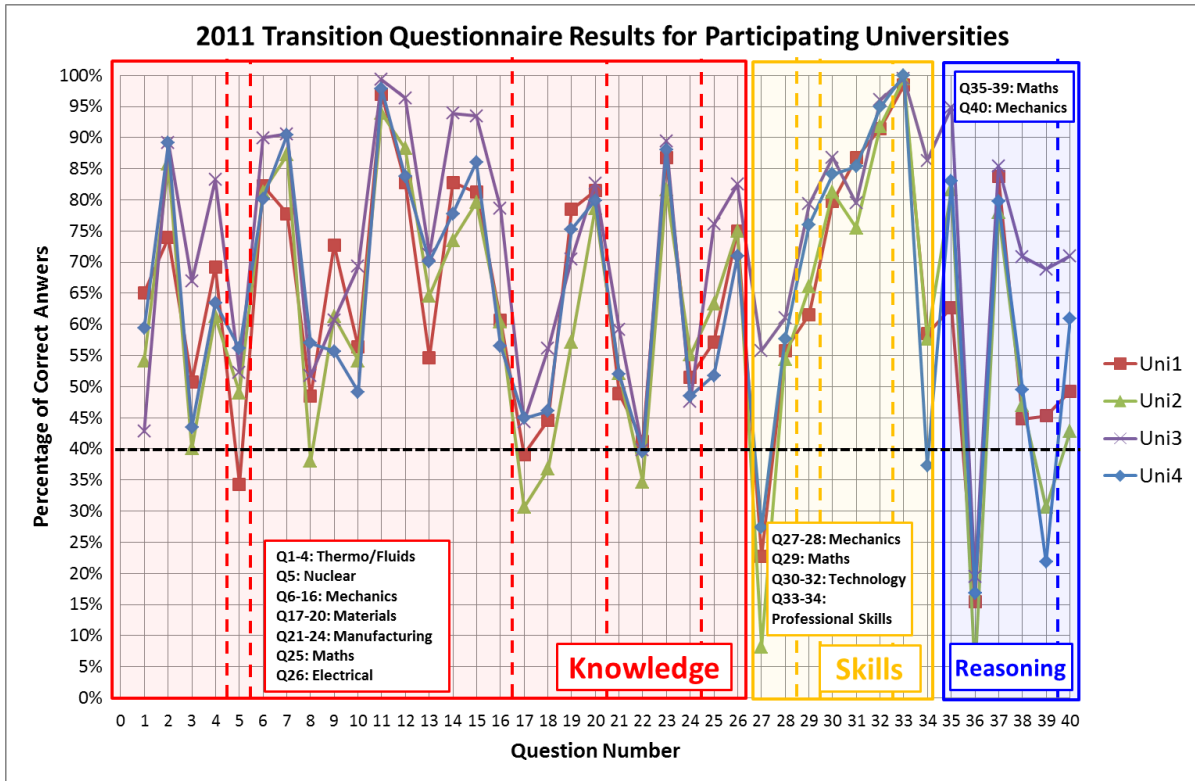


Figure 1. Transition Questionnaire Results for Four UK Engineering Schools in 2011

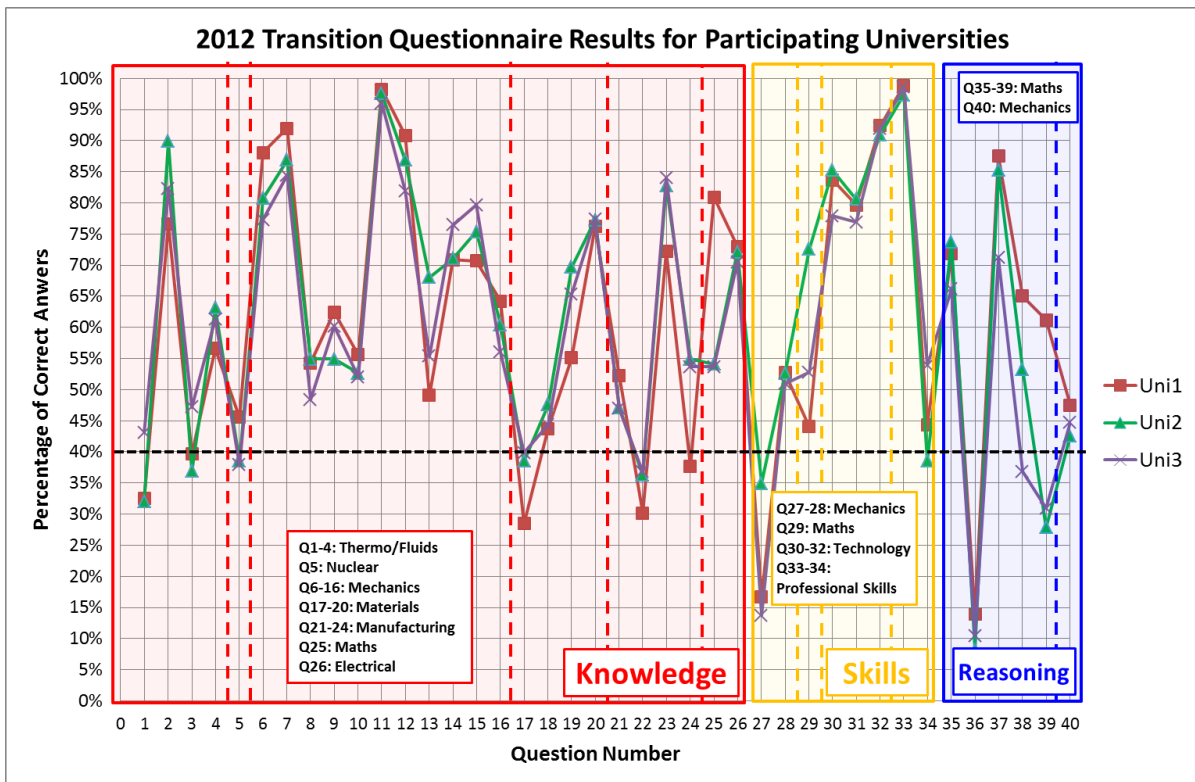


Figure 2. Transition Questionnaire Results for Three UK Engineering Schools in 2012

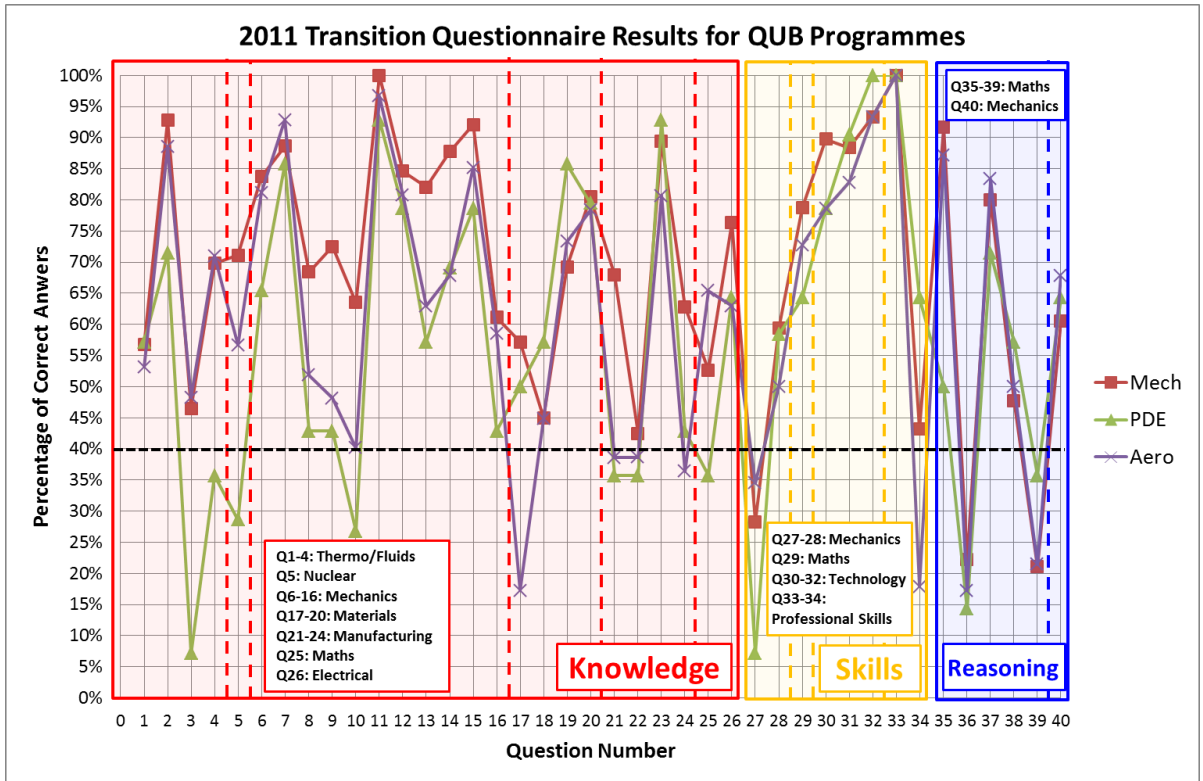


Figure 3. 2011 Transition Questionnaire Results for the Three Engineering Programmes at QUB: Mechanical (Mech); Product Design (PDE); Aerospace (Aero)

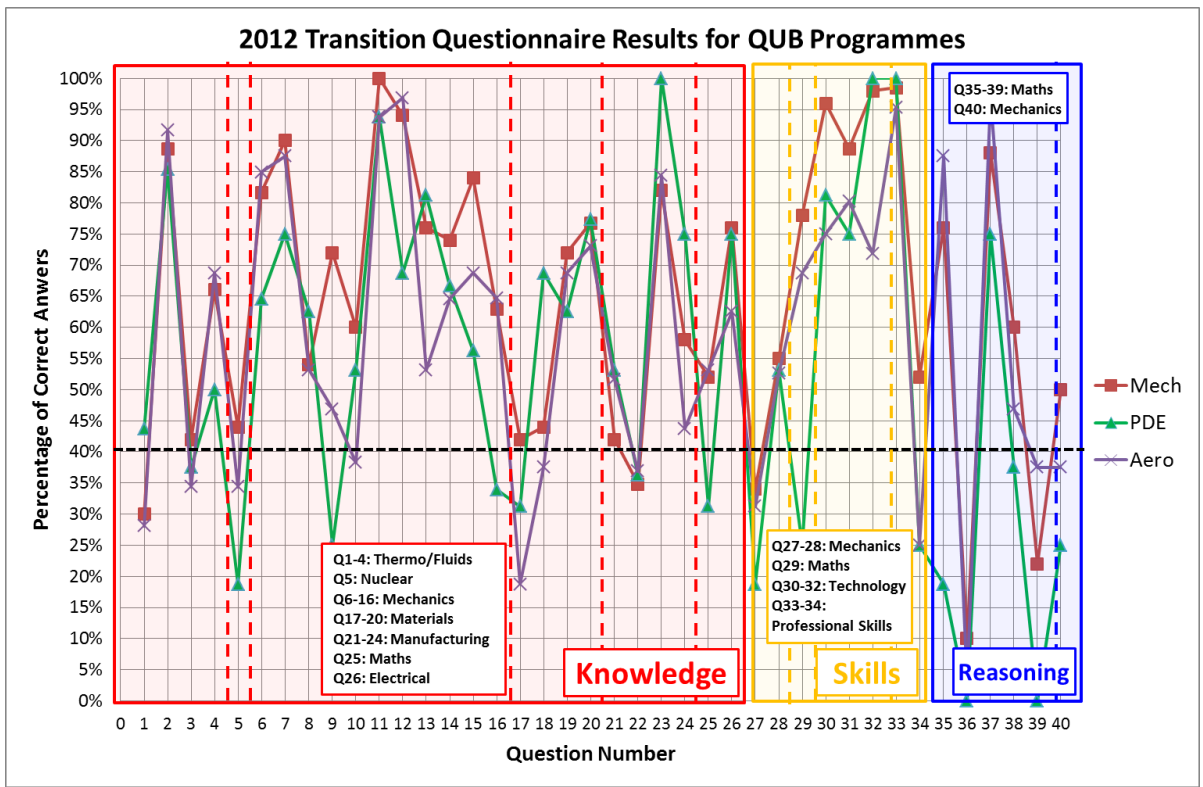
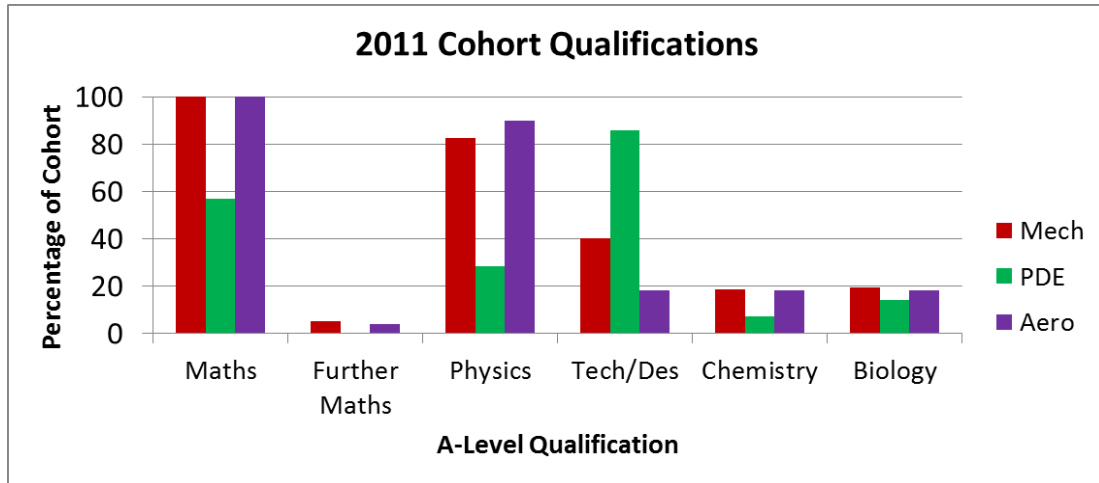
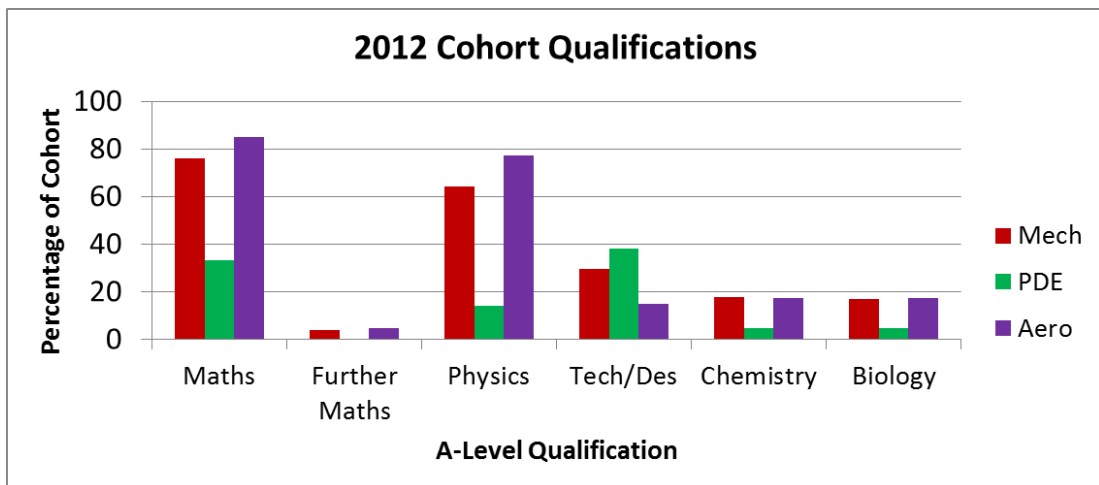


Figure 4. 2012 Transition Questionnaire Results for the Three Engineering Programmes at QUB: Mechanical (Mech); Product Design (PDE); Aerospace (Aero)



MECHANICAL ENGINEERING						PRODUCT DESIGN ENGINEERING						AEROSPACE ENGINEERING								
Subject	Grade (%)					Total	Subject	Grade (%)					Total	Subject	Grade (%)					Total
	A*	A	B	C				A*	A	B	C				A*	A	B	C		
Maths	10	51	33	6		100	Maths	0	14	36	7		57	Maths	10	45	39	6		100
Further Maths	1	2	0	2		5	Further Maths	0	0	0	0		0	Further Maths	0	0	4	0		4
Physics	2	25	31	25		82	Physics	0	0	14	14		29	Physics	2	16	47	24		90
Tech/Des	4	21	11	4		40	Tech/Des	7	29	43	7		86	Tech/Des	4	4	10	0		18
Chemistry	2	3	8	5		19	Chemistry	0	0	7	0		7	Chemistry	0	0	2	16		18
Biology	0	10	7	2		20	Biology	0	0	7	7		14	Biology	2	6	8	2		18

Figure 5. 2011 Entrance qualifications: A-Level Subject Percentages for School of Mech. & Aero at QUB



MECHANICAL ENGINEERING						PRODUCT DESIGN ENGINEERING						AEROSPACE ENGINEERING								
Subject	Grade (%)					Total	Subject	Grade (%)					Total	Subject	Grade (%)					Total
	A*	A	B	C				A*	A	B	C				A*	A	B	C		
Maths	7	37	31	1		76	Maths	0	10	19	5		33	Maths	8	28	48	3		85
Further Maths	1	2	1	1		4	Further Maths	0	0	0	0		0	Further Maths	5	0	0	0		5
Physics	3	18	27	16		64	Physics	0	0	10	5		14	Physics	8	15	40	15		78
Tech/Des	4	16	10	0		29	Tech/Des	5	33	0	0		38	Tech/Des	3	3	8	3		15
Chemistry	1	5	7	5		18	Chemistry	0	0	0	5		5	Chemistry	5	0	8	5		18
Biology	0	6	9	2		17	Biology	0	5	0	0		5	Biology	0	5	13	0		18

Figure 6. 2012 Entrance qualifications: A-Level Subject Percentages for School of Mech. & Aero at QUB

Figures 5 and 6 each show three tables listing the percentages of students enrolling in 2011 and 2012 respectively with specific grades in A-Level qualifications relevant to the same three engineering programmes at QUB: Mechanical Engineering (Mech); Product Design Engineering (PDE); Aerospace Engineering (Aero). These figures also present summary bar charts of the “Total” columns in the tables, so that the percentage breakdown of general entrance qualifications can be readily understood.

DISCUSSION AND CONCLUSIONS

Figure 1 shows the Transition Questionnaire results from four participating institutions at the beginning of the 2011 academic year. At QUB the questionnaire was timetabled in computer suites during ‘welcome week’ – the week before classes commence. This ensured that nearly 70% of all new students were able to complete it under supervision. The other institutions involved presented the questionnaire in different ways, but managed to ensure over 50% completion rate - Response rates were better when the exercise was carried out in a timetabled class session. The following year (2012) the other institutions adopted this more formal approach, which ensured an increased participation, with QUB achieving close to 70% again. Both figures 1 and 2 succeeded in verifying that there were very similar trends in answers from each of the institutions, which was expected as they are all engineering schools offering similar courses.

It can be seen from figures 1 and 2 that there are several questions that caused particular problems for all participating students with scores of 40% or less: questions 22, 27 and 36. From table 1, these questions were on the topics: Manufacturing - production processes; Mechanics – units; Maths - comprehension and percentages.

These problems can be analysed in more detail for the QUB students in 2011 and 2012 by referencing figures 4 and 5 respectively where, amongst other issues, these three questions stand out. Figures 5 and 6 provide information on the background qualifications of these QUB students and it can be seen that, for both years 2011 and 2012, a very high percentage of the mechanical and aerospace students have high grades in mathematics and physics A-levels. Therefore it is perhaps surprising that they should struggle on the maths and mechanics questions.

However, further reference to figures 4 and 5 reveal that there are several other surprising areas that have caused problems. The aerospace students also struggled with questions 17, 21, 24, 34 and 39 in 2011, and questions 1, 3, 5, 10, 17, 18, 34, 39 and 40 in 2012. For the mechanical students it was question 36 in 2011 and questions 1, 36 and 39 in 2012. It should be noted that in most of the questions scoring less than 40% a significant number of students chose the “not sure” option as an answer.

There has been no mention of the product design students in the discourse so far as they presented with less background skills in mathematics and physics in these two years. Despite this, over the two years they did present with relatively more experience in technology and design (Tech/Des) and consistently outscored the other students in questions 18, 23, 32 and 33.

It is appreciated that these results may not be statistically viable, but the trends that have consistently presented in the questionnaire over several years could fill many more pages of discussion on the results. The purpose of this transition project for the collaborators was to

gain awareness of the relevant skills and attributes of the students enrolling on their engineering courses and to be in a position to react and evaluate their relevant curricula, specifically in areas where perceived skills and attributes were lacking. The questionnaire was taken by first-year students who were already enrolled on these engineering courses and who had achieved the necessary entrance requirements. Therefore, the level of results analysis will be pertinent to each of the collaborating universities to facilitate their own reactive curriculum changes. It should be noted that after the initial implementation phase of the project, the collaborators agreed to include several “easy” questions to keep the students motivated to complete the questionnaire, and which consistently produced correct answers.

The important fact is that these results have informed the ongoing curriculum reform in the School of Mechanical & Aerospace Engineering at QUB. They have sparked further investigations into entrance qualifications (Cole & McCartan, 2013) and have positively affected programme reviews, helping meet overall objectives to accommodate transition, improve the learning experience and increase retention.

Using this tool or a similar process means that institutions can quickly identify areas of academic and practical strengths and weaknesses, allowing the support of entrants from the beginning of their undergraduate studies. In principle, the tool can be used by first-year lecturers, by those reviewing engineering programmes, so that they routinely adapt to match the skills and experience of each incoming cohort, by students themselves and by potential students applying for engineering courses.

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BIOGRAPHICAL INFORMATION

Charles McCartan is a senior lecturer in the School of Mechanical and Aerospace Engineering at Queen's University Belfast. His scholarly interests include developing, applying and evaluating active and interactive learning methods, teaching mathematics to engineers, first year introductory courses, the assessment of group projects and the transition from school to university. In addition, he is a professional engineer with experience in industry, research and consultancy. He is a member of the Society of Automotive Engineers (SAE) and a Fellow of the Higher Education Academy (HEA).

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