Gifted first year engineering students: curriculum preferences

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***Abstract**: As first year engineering classes expand with a first year cohort of increasingly diverse abilities, aptitudes and achievements, designing the appropriate level of challenge and support for all students, especially the gifted and talented, is a difficult task. This paper reports on a study that surveyed first year engineering students at one Australian university to determine the curriculum differentiation options preferred by the students and compared the preferences of gifted and talented students with their peers. The top five options chosen by the students are presented. A greater consistent engagement with the engineering workplace was clearly sought.*

Introduction

Students identified as gifted and talented in compulsory education are required to be offered a differentiated curriculum based on their characteristics. These characteristics, when compared to their age peers, include learning at a quicker rate, seeking greater challenge, applying greater concentration to areas of interest, studying with greater intensity and energy, a preference for working independently, heightened sensitivity, greater empathy, sense of justice, multiple interests, more quickly understanding the relationships between ideas and concepts, and a greater ability to generate original ideas (VanTassel-Baska, 1998). There is no requirement to differentiate the curriculum once gifted and talented students enter post-compulsory education.

At the same time, gifted and talented students enrolling at university find themselves amongst a first year cohort of increasingly diverse abilities and achievements (e.g., King, 2008). The Australian Government's ambition for 40% of all Australian 25 to 34 year olds to have a qualification at Bachelor level or above by 2025 (Gillard, 2009) challenges universities to rethink their intake policies and consider accommodating a larger number of enrolments. With a larger intake, the abilities, aptitudes and achievements in the incoming first year student cohort is expected to broaden. Catering for this range of abilities, aptitudes and achievements is a challenge for those developing the first year curriculum.

Sanford (1962), Upcraft (2005) and Kift's first year curriculum design principles (2009) emphasise the importance of designing first year university programmes so that students experience appropriate challenges and supports. For the struggling first year student, strongly challenged by the first year curriculum, many Australian universities already provide a range of support programmes and activities. However, the range of programmes and activities for the first year student who is not appropriately challenged by the first year curriculum is more limited.

This paper discusses the preferences of gifted and talented first year engineering students and their peers towards a range of possible first year engineering curriculum differentiation options. In this study students were asked if they had previously been identified as gifted and talented, as some students may have been formally assessed at school. Other students may not have had the opportunity to be tested, so an additional question asked if they thought they were gifted and talented. This question allowed these students to reflect and identify themselves as gifted and talented. The acronym SIG is used in this study to describe those *S*elf-*I*dentified *G*ifted and talented. The acronym SInG is used in this study to describe those *S*elf *I*dentified *N*ot *G*ifted and talented.

There are many definitions of gifted and talented. This study uses the Gagné (2003) definition of gifted and talented – in the top 10% of age peers – as typically used in Australian primary and secondary schools (e.g., Gross et al., 2005; State of Victoria (Department of Education and Early Childhood Development), n.d.).

Variation in Engineering Students' University Entrance Scores

Robin King's report, "*Addressing the supply and quality of engineering graduates for the new century*" commented on the variety of incoming students' university entrance scores or University Admissions Index (UAI), where the UAI is an equivalent ranking out of 100. The UAI is called the TER (Tertiary Entrance Rank) in New South Wales and Western Australia, OP in Queensland and ENTER in Victoria (King, 2008, p. 145). For example, a student with a UAI of 65 achieved as well as or better than 65% of the Year 12 school leaver age population.

Table 1 shows the UAI entrance scores for engineering in Western Australian universities. Students studying a combined degree, engineering with another subject, would typically need to achieve a higher UAI that students studying the single engineering degree. Attending a first year engineering class at the University of Western Australia (UWA), for example, will be students studying engineering and law who achieved a university entrance score of 97. Another student in the same class could have achieved a university entrance score of 84, enrolled in the engineering only programme. The same spread of university entrance scores could apply at Edith Cowan University (ECU), where a student studying engineering and law, requiring a UAI of at least 80, is likely to be in the same class as a student studying engineering only, achieving a UAI of 65. As King (2008) noted, some of these students may also have not previously studied advanced level mathematics. Ensuring both groups of students are adequately challenged and supported in their first year is a task entrusted to the first year engineering teaching team.

Table 1 Published UAI cut-off scores for entry to Bachelor of Engineering degrees and selected dual degrees in Western Australian universities for admission in 2010 and 2009.

	2010			2009		
University	UAI for single B.Eng	UAI for dual engineering and Science	Law	UAI for single B.Eng	UAI for dual engineering and Science	Law
Curtin	80	80	-	80	80	-
ECU[a]	70	75	80	65	70	80
Murdoch	70	70	80	70	70	-
UWA[b]	84	88	97	84	88	96.3

Note: Data from (Tertiary Institutions Service Centre, 2011)
University Names: [a]ECU: Edith Cowan University; [b]UWA: University of Western Australia.

As well as the range of achievements amongst the first year engineering cohort, there is a range of abilities. Some first year engineering students had been identified as gifted and talented in primary or secondary school. In primary and secondary school, in line with Education Department Policy, gifted and talented students would have had the opportunity to study a modified or differentiated curriculum (e.g., [WA] Department of Education, 2009, 2010; Senate Employment, 2001). Once at university, however, curriculum differentiation for those identified as gifted and talented is rare, with the same curriculum delivered to all first year students regardless of ability. This 'one-size-fits-all' curriculum might not be of concern to gifted and talented students at university, who may be satisfied with the level of the offered curriculum (Peine, 2010). Alternatively, curriculum uniformity could indeed be a problem (Benbow & Stanley, 1996) with the gifted and talented student not feeling appropriately academically challenged.

Variation in Engineering Curriculum

University engineering schools have developed various provisions for high performing students. These include leadership programmes, honours colleges, curriculum compaction, curriculum acceleration, classes between semesters and on-line learning materials.

In the USA, the Massachusetts Institute of Technology (MIT) offers their outstanding engineering students the extra-curricular 'Bernard M. Gordon - MIT Engineering Leadership Program' (MIT, 2010b). In Australia, an engineering leadership programme is available at Monash University with the extra-curricular Monash University Engineering Leadership (Monash University, 2010). Finally, broader than just engineering students, the Griffith University Griffith Honours College offers an extra-curricular enrichment programme that includes leadership (Griffith University, 2010).

Honours College or Honours programmes are offered by some USA universities for high performing students. Some activities are extra-curricular and others include studying selected units at honours level, a higher level, with additional assessment tasks (e.g., Purdue University, 2011). An Australian example is the Griffith Honours College. In Europe, the University of Groningen recently introduced an Honours College for the top 10% of their students (Suhre & Jansen, 2011). While USA Honours programmes allow some modifications to the core curriculum, both Griffith and Groningen Honours Colleges are extra-curricular. In contrast, the University of Western Australia's four-year Bachelor of Philosophy (Honours), or 'BPhil(Hons)' is a dedicated curriculum but only for a small group of students. "A challenging and prestigious program for high-achieving students" (The University of Western Australia, 2010), the BPhil(Hons) is offered to about 30 students each year with an university entrance score of 98 or more.

The University of Auckland allows their high achieving students to modify their curriculum. Engineering students with high Grade Point Equivalent scores may be invited to complete the full requirements of the Degree of Bachelor of Engineering (Honours) over three years instead of four (The Calendar and Regulations Office, 2011).

A Bachelor of Engineering can also be completed in three years at the University of South Australia. The University of South Australia recently restructured its engineering programmes to allow for curriculum acceleration, where, after the common first year, units can be completed in holiday periods instead of taking a break, allowing a typical four year engineering degree to be completed in three years (University of South Australia, 2009). Units in holiday periods are open to all students.

Parts of the engineering curriculum are available on-line, and often at no charge. Free videos of engineering lectures, learning materials and exams are available through, for example, MIT's Open Course Ware (MIT, 2010a), Carnegie Mellon University's (CMU) Open Learning Initiative (Carnegie Mellon University, 2010) and Stanford University's Stanford Engineering Everywhere (SEE) initiative (Stanford School of Engineering, 2009), as well as other portal sites (Academic Earth, 2010; Young, 2008, January 25).

Aim of the Study

The aim of this study was to determine the curriculum differentiation preferences of gifted and talented first year engineering students. The students' preferences may inform first year engineering curriculum writers of possible ways to challenge and support the gifted and talented first year engineering student.

Theoretical Framework

Differential psychology seeks to understand variation in how people feel, act, think and want and people classified as elite, exceptional or gifted and talented are a well researched group (Gagné, 2003; Silverman, 1993; Terman, 1926). The differential psychologists and educators studying the gifted and talented acknowledge that this group has traits, abilities and characteristics that separate them from their peers (e.g., Dąbrowski, 1967; VanTassel-Baska, 1998). From the theoretical perspective of differential and individual difference, gifted and talented students would be expected to value some learning experiences differently from their peers. The individual difference theoretical perspective and studies into the characteristics of gifted and talented students formed the framework for this study.

Methodology

A survey research design was utilised. This design captures the attitudes of a large number of people in a quick, easy to use, and anonymous process. The research was based on the attitudes of first year engineering students at one site, at the start of Semester 2, 2010.

Method

The method chosen to gather the student preferences was an on-line questionnaire. Following a process described by Bennett and Nair (2009) personalised emails from senior members in the faculty, and reminder emails timed to reach students just before the start of the weekend, were used to inform students of the survey.

Part of the questionnaire was a list of 17 curriculum differentiation options. Some of these included options previously or currently offered by engineering schools: leadership programmes, both curricular and extra-curricular; curricular timing flexibility by compressing the curriculum, studying a unit between semesters; work-shadowing; and being part of a smaller group at the start of semester. Other options, based on the characteristics of gifted and talented students mentioned at the start of this paper, were added. The 17 curriculum differentiation options were presented in a question "In my studies so far, I would have liked the opportunity … (select as many as apply)". A free form text field, "Other", allowed students to add any other options. Preferences were not ranked, and students were free to choose multiple curriculum differentiation options. Another free form text field allowed students to include additional comments.

Responses from SIG first year engineering students were compared to the responses of the SInG first year engineering students. Trends in the first year engineering group as a whole were also noted.

Results

The survey response rate was 21% (n = 767, with 160 usable questionnaires). Eighty four (84) of the survey respondents identified themselves as gifted and talented, and 76 survey respondents identified themselves as not gifted and talented. The curriculum differentiation part of the questionnaire was completed by 128 students, 66 SIG and 62 SInG.

Table 2 shows the 17 curriculum differentiation options, and how many times the options were chosen by SIG and SInG students. The top five most popular curriculum differentiation options for SIG and SInG students were compared, and four options were found in both lists: to work-shadow in an engineering firm; to work on an independent project with an engineer; the opportunity to do some research into an area of interest; and to be part of a smaller group at the start of Semester.

Table 2 Curriculum Differentiation Options: SIG (*n* = 66) and SInG (*n* = 62) Responses

Option	Description	No of times chosen	SIG	SInG
11	To work-shadow (say one day a fortnight) in an engineering firm.	87	44	43
16	To be part of a group that took on-line engineering lectures from MIT, Stanford, etc	46	32	14
3	To work on an independent project with an engineer	57	29	28
8	To be part of a smaller group at the start of Semester.	59	28	31
9	The opportunity to do some research into an area of interest	55	28	27
12	To study a unit on culture, society, theology, philosophy or other non-engineering	40	25	15
4	To be part of an extra-curricular leadership programme (in addition to my normal units)	30	23	7
6	To be part of some other extra-curricular programme, not leadership based (e.g., programmes on justice, philosophy, human behaviour, oceans, etc)	41	23	18
17	To have more one-on-one time with lecturers	45	22	23
15	To be part of a curricular engineering programme (as part of to my normal units)	44	21	23
7	To be part of some other curricular programme, not leadership based (e.g., programmes on justice, philosophy, human behaviour, oceans, etc)	30	20	10
10	To study a unit between Semester 1 and Semester 2	30	19	11
1	To have started my studies earlier (e.g., during the summer break)	31	18	13
5	To be part of a curricular leadership programme (as part of my normal units)	33	17	16
14	To be part of an extra-curricular engineering programme (in addition to my normal units)	34	17	17

13	To compress my studies and finish first year early.	24	16	8
2	To sit my exams early so that I can move to more challenging subjects sooner	13	9	4

Three students used the questionnaire's additional comments field to emphasise the how valuable they saw the opportunity to work-shadow. As one SIG student stated:

> Also as I indicated in the survey, going to an engineering firm and shadow-working with an engineer would priceless for a first year engineering student. Not only would we appreciate it and support it as it gives practical skills; but it shows us what we may be doing once we complete our degree; perhaps opening some students eye's who thought engineering was something different; possibly saving that student from 4 years of wasted education when they finish their degree and get a job and find out engineering was not what they thought it would be (or even in their third or fourth year when they begin their project). If we worked well with the engineer as well a job opportunity could offered and future employment guaranteed after graduation. (ID4)

The second most popular option for the SIG engineering students was to be part of a group that took on-line engineering lectures from MIT, Stanford, etc. This option was the 11th most popular for the SInG respondents.

The fifth most popular option for the SInG engineering students was to have more one-on-one time with lecturers. This option was the 9th most popular for the SInG respondents.

The first curriculum differentiation option around leadership, "To be part of an extra-curricular engineering programme (in addition to my normal units)" was 7th most popular for SIG, and 8th most popular for SInG.

Discussion

While the study sought to determine the curriculum differentiation options preferred by gifted and talented first year engineering students, some consistent preferences were noted. The desire for greater engagement with the engineering workplace, either through work-shadowing, or working with an engineer, was the highest preference for all first year engineering students. A challenge for first year engineering curriculum writers is to consider how to include consistent engagement with the engineering workplace as part of the first year curriculum, in addition to the typical foundation mathematics, physics and engineering science units.

Being a part of a smaller group at the start of Semester was also a consistent preference for all students. This may be a comment on the well-known first year large lectures and other large classes. Similarly, the opportunity to do research in an area of interest was in the top five preferences for both SIG and SInG students. This may be in response to the typically prescribed nature of the first year engineering year curriculum.

Also consistent across the student groups was what was not in the top five – leadership programmes. Extra-curricular leadership programmes were preferred to curricular leadership programmes. Universities offering their high achievers leadership programmes may, in fact, not be providing what these high achievers prefer at this stage.

There are some differences between the groups of students. SIG students chose as their second most popular preference 'To be part of a group that took on-line engineering lectures from MIT, Stanford, etc'. The preference for more challenging work, and to be with similarly motivated students, is a consistent characteristic of gifted and talented learners.

Conclusions

Catering for the needs of a larger student cohort with a diverse range of abilities and educational achievements is a challenge for first year university curriculum writers. While some principles of first year curriculum design have been well researched, catering for diversity is still poorly implemented, especially for the best and brightest students.

All first year engineering students who participated in the survey identified the desire for greater consistent engagement with the engineering workplace from the beginning of their studies. All

students also highly valued being part of a smaller group of students, and the opportunity to do some research into an area of interest.

The gifted and talented first year engineering students in this cohort sought greater curricular challenges, either through additional material available on-line or through a broader, non-engineering curriculum. Leadership programmes were not highly preferred at this stage. It seems dedicating resources to consistent engagement with the engineering workplace challenges and supports both gifted and talented students and their peers at this stage of their studies.

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