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Students acknowledge that deep assessment types improve engineering graduate attributes: Shallow learning still prevails

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BACKGROUND
In response to the common goal of enhancing the overall skills of engineering graduates, a large body of literature relating to the study of student approaches to learning and assessment has developed. In a similar vein, there is also an area of research focussed on identifying and developing methods of improving graduate outcomes. Typically, previous studies have focussed on only one of these topic areas. This study analyses the interwoven link that connects all three aspects of student learning.

PURPOSE
This study presents one of the first attempts to link a students' approach to learning and assessment type preferences to Engineers Australia graduate attributes. Students also provided their perceptions on the extent to whether their approach to learning and assessment type preferences correlated to professional attributes such as their ability to communicate and their capacity for lifelong learning. Literature reviews on the beliefs of the engineering industry at large has reinforced the notion that strongly desired graduate attributes such as the capacity for innovative thinking is not being instilled within today's engineering graduate. This paper is part of an ongoing investigation into the design of new teaching and assessment methods designed to foster a deep-learning approach. Before this can be achieved, the hypothesised mismatch between many students' preference for recall type assessment and their acknowledgement that multi-faceted critical thinking types of assessment improve their graduate attributes needs to be empirically reconciled.

DESIGN/METHOD
Data was collected through a student survey of 132 second year civil engineering students. The questionnaire was comprised of five main sections: Part A collected basic student demographic information; Part B was designed to elicit the students' view on their own personal approach to learning; Parts C and D were structured in a similar way to collect the students' assessment preferences; and Part E was designed to elicit information about how students perceived the extent to which different assessment types are linked to the development of graduate attributes. Using Biggs' *et al*., (2001) Revised Study Process Questionnaire, students were first classified into one of two primary groups, namely, having either a Surface Learning Approach (SLA) or Deep Learning Approach (DLA). Students were also either classified as having a Surface Assessment Preference (SAP) and Deep Assessment Preference (DAP). Clustered groupings of students based on their SLA, DLA, SAP and DAP were mapped against students perceptions on how Surface Assessment Types (SAT) and Deep Assessment Types (DAT) contributed to Engineers Australia graduate attributes.

RESULTS
This paper examines the tripartite relationship between the approach to learning, assessment type preference and graduate outcomes. Results indicated that there is a mismatch between many students preference for SAT and their acknowledgement that the multi-faceted critical thinking DAT assessment (e.g. PBL) contributes to improved engineering graduate attributes.

CONCLUSIONS
The findings reveal that engineering students acknowledge that instilling deep learning skills is essential to be an effective engineering graduate that is embraced by industry. However, many second year engineering students still have a short-term focused preference for assessment that is highly defined. Furnishing empirical evidence on this mismatch is the first step to acknowledging this issue. The study indicates that Engineering Schools need to work with high schools to encourage deeper learning and continue to foster this style of learning at the outset of the engineering program to ensure that short-term goal orientated learning approaches do not become entrenched.

KEYWORDS
Learning preferences, assessment preference, engineering graduate attributes

Introduction

The overall purpose of this paper is twofold: (1) to examine the approaches to learning of the second year engineering student cohort; and (2) to assess the magnitude of the link between a students' assessment type preference and the development of graduate attributes. The purpose of this study is therefore quite unique within the published literature as whilst there is a significant body of research in each individual area (approach to learning, assessment type preference and graduate attributes); there is a distinct paucity of data which attempts to distil relationships between these three separate areas. It is the authors' hypothesis that in order to develop the required critical and deep learning approaches in engineering students, an understanding of the psychological makeup of the student cohort is necessary before programs can be designed to overcome perceived problems.

Approach to Learning

There is no doubt that the study of student approaches to learning is a common research topic within the literature. For instance, Stappenbelt (2010) postulates that "action learning" supports the development of a deep approach to learning and produced a "positive effect" on student learning. A deep approach to learning is one of the foundations of being a lifelong learner (Baeten, *et al*., 2008), and as a consequence, there is no argument that the modern university graduate needs a deep learning approach to have the ability to succeed in the modern world (Male *et al*., 2010).

Assessment Preference

The engineering professional infers by its very nature, an innate, instilled and heightened deep assessment preference and approach to learning over and above other disciplines (Heller, *et al*., 2010). However, students in general prefer surface type assessment (Van de Watering, *et al*., 2008). This mismatch between the long-term needs of the engineering profession and the short-term desires of busy students is currently being won by the students.

Graduate Attributes

It is often identified in the literature that students are aware of the need for them to develop graduate attributes (Nghiem et al. 2010; Maier and Rowan, 2007; Ashman, et al. 2008), and engineering graduates themselves have provided their thoughts as to the desirability of graduate attributes (Passow, 2012). Similarly, there is much published literature on the necessity of instilling graduate attributes into the modern university student (Nghien, et al. 2010; Bullen et al. 2004), and methods by which this might be able to be achieved including: peer assessment (Gomes et al. 2008); games used in the teaching of sociology (Goh, 2012); while Shen et al. (2011) suggested that "self-reflection" through the use of ePortfolios might assist. It has recently been reiterated that there is no issue in identifying which graduate attributes engineering students require, but that the real problem is how to teach them (e.g. Shen et al. 2011).

The Tripartite Relationship

The study described herein provides a study into the views of the students as to what types of assessment they think leads to the development of graduate attributes. There is a paucity of research data in relation to the link between a students' approach to learning, their assessment preference and graduate outcomes. Understanding how this tripartite relationship is linked is vital to being able to develop assessment to develop the required graduate attributes. It is the authors' contention that that although this link is not a novel idea, there is a paucity of published experimental data to assist in quantifying the relevant links and therefore lead to the development of mechanisms to develop those types of assessment that lead to graduate attributes.

Objectives

This paper sought to empirically confirm anecdotal evidence that a large proportion of 2nd year engineering students adopted a shallow learning approach and/or had shallow assessment preferences even though they understood that deep assessment types better improved their Engineers Australia (EA) graduate attributes and employment readiness. Based on this overall goal of the study, the following objectives of this research investigation are as follows:

1. Create a clustered comparison of the assessment preferences of 2nd year engineering students based on their learning approach;
2. Determine whether 2nd year engineering students acknowledge that deep assessment types improve their EA graduate attributes and associated job readiness; and
3. Compare students having different clustered combinations of learning approaches and assessment preferences with their opinion on whether surface or deep assessment types lead to improved graduate attributes.

Methodology

Participants

Data for this study was collected through a student survey of a second year civil engineering core course. This paper uses discrete portions from the large data set obtained from that survey to build on the authors preliminary investigations as published previously (Stewart and Walker, 2011). Consent forms and questionnaires were administered at the commencement of a scheduled lecture period and participants were required to read the information schedule prior to completing the survey. Questionnaires were eliminated from the analysis if it appeared obvious that the student had not completed it properly or it had excessive missing data. A total of 132 respondents or (92% of the total students enrolled in the course) completed the questionnaire.

As can be seen in Table 1, 66% of the cohort was in their third semester of study (the start of the second year of the four year engineering degree). Unsurprisingly 88% of the group were male and the majority of students were recent secondary school graduates (1 year), with 57% within the 18-20 age group followed by 32% in the 21-23 age group. Being a young group it was not surprising that 72% had no prior industry experience with 17% having 0-6 months of industry experience. Interestingly 33% of the students identified as having English as a second language. International students often make up around 20-30% of engineering courses at the University.

Table 1: Details of participants

Age (Years)	Percent	Industry experience (including work experience)	Percent	Semester of engineering study	Percent
18-20	57	None	72	1st Sem	6
21-23	32	0-6 months	17	2nd Sem	5
24-26	8	7-12 months	2	3rd Sem	66
27-30	2	1-2 years	5	4th Sem	10
31-40	1	3-5 years	3	> 4th Sem	13
		5+ years	1		

Questionnaire instrument

The questionnaire was comprised of five main sections: Part A collected basic student demographic information; Part B was designed to elicit the students' view on their own personal approach to learning; Parts C and D were structured in a similar way to collect the students' assessment preferences; and Part E was designed to elicit information about how students perceived the extent to which different assessment types improve the development of graduate attributes.

Part B: Student approaches to learning

Using Biggs' *et al*., (2001) Revised Study Process Questionnaire, the approaches to learning section (Part B) consisted of 20 items designed to classify students into two primary groups, namely, having either a Surface Learning Approach (SLA) or Deep Learning Approach (DLA).

The 20 Likert-type items were graded on a 5-point scale where 1 = "*This is never or only rarely true of me*" and 5 = "*This is always or almost always true of me*". Table 2 provides some examples of types of questions as detailed in Bigg's *et al*., (2001) questionnaire. For a student to be classified as having a DLA their mean survey responses needed to satisfy two criteria: (a) the aggregate mean of their responses to Deep Learning type questions needed to be equal or greater than 3.00; and that (b) this aggregate mean DLA value was greater than their aggregate mean SLA value.

Table 2: Student approaches to learning question examples

	Part B: Student approaches to learning
Deep Learning Approach (DLA)	"I find that at times studying gives me a feeling of deep personal satisfaction"
	"I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied"
Surface Learning Approach (SLA)	"My aim is to pass the course while doing as little work as possible"
	"I only study seriously what's given out in class or in the course profile"

Parts C and D: Assessment type and question type preferences

The assessment type preference (Part C) and assessment question type preference section (Part D) consisted of 31 Likert-type items graded on a 5-point scale where 1 = "*Not at all*" and 5 = "*To a very great extent*". Table 3 provides some examples of typical questions included in Parts C and D of the questionnaire.

SAP types of assessment included quizzes; tutorial assignments; defined laboratories and field work; short technical reports; examinations on course material; and, technical reports on defined problems. DAP types included major design tasks with multiple possible solutions; major examinations requiring problem solving and application of prior knowledge and complex laboratory/field work; and, critical thinking/and judgement to solve multi-faceted engineering problems in an assignment or exam situation.

For analysis purposes the mean aggregate from *the combined* Parts C and D was calculated for each student to determine a value for their Surface Assessment Preference (SAP) and Deep Assessment Preference (DAP).

Table 3: Assessment methods question examples

	Part C: Assessment type preferences	Part D: Assessment question type preferences
SAP	"I prefer module tests (quiz)" "I prefer short multiple choice examinations"	"I prefer questions requiring the reproduction of facts" "I prefer questions that require comparing different concepts/ideas"
DAP	"I prefer an engineering design assignment having multiple possible solutions" "I prefer major exams with questions requiring problem solving and application of course material to relatively new situations"	"I prefer questions requiring the application of material learnt to new situations" "I prefer questions that require an overall view of the relationships between all topics learnt"

Part E: Assessment link with graduate attributes

The assessment link with graduate attributes section (Part E) consisted of 16 questions requiring the student to rate the degree to which they believed their engineering graduate attributes would be improved by certain types of assessment (either SAT or DAT type assessments). The cross-correlation was graded on a 5-point scale where 1 = "*Not at all*" and 5 = "*To a very great extent*". Table 4 provides some examples of typical graduate attributes included in Part E of the questionnaire.

Table 4: Assessment link with graduate attributes question examples

Example graduate attribute	SAT	DAT
P1: Knowledge Base Knowledge of science and engineering fundamentals	Rank 1-5	Rank 1-5
P2: Engineering Ability Ability to undertake problem identification, formulation and solution	Rank 1-5	Rank 1-5
P3: Professional Attributes Ability to communicate effectively with the engineering team and with the community at large	Rank 1-5	Rank 1-5

For analysis purposes the mean aggregate from the 16 questions for columns SAT and DAT were calculated, thus producing a single overall ranking for the effect of surface assessment types on the improvement of graduate attributes and similarly a single overall ranking for the effect of deep assessment types on the improvement of graduate attributes. In Figures 1 and 2 in the following Results section, it is this mean aggregate value that is represented on the Y-axis in each figure.

Results

The main focus of this paper was to examine the correlation between a second year engineering students' assessment type preference and perceived impact of that type of assessment on the improvement of graduate attributes.

Student learning approaches and assessment preferences

Stewart and Walker (2011) correlated Part B findings with that of C and D in a prior paper. This prior work indicated that DLA type students have greater enthusiasm toward all forms of assessment in general, which sets them apart from SLA learners. Conversely, students in the SLA cluster (62% of total cohort) lacked general motivation towards either type of assessment activity, but when given the choice would likely choose surface learning based assessment. This present study is focused on linking these learning and assessment preferences to students' perceptions on how certain assessment types improve graduate attributes. Figure 1 shows that in the dominant SAP group (60% of total cohort), even though their preference for DAP is comparatively low, they show a significant change in their response in Figure 1, showing that they do inherently know that DAT improves their graduate attributes (*t*-test; $p<0.05$). Unsurprisingly, the majority of students in the DAP grouping more strongly acknowledge that DAT improves their graduate attributes (Figure 1). Most importantly, Figure 1 also indicates that while surface learners contain an innate dislike for deep, critical thinking they are also very aware of what graduate attributes are, and that deep assessment types will improve their job prospects through their graduate attributes. In the face of this mindset, the challenge to engineering education professionals is how to change this preference.

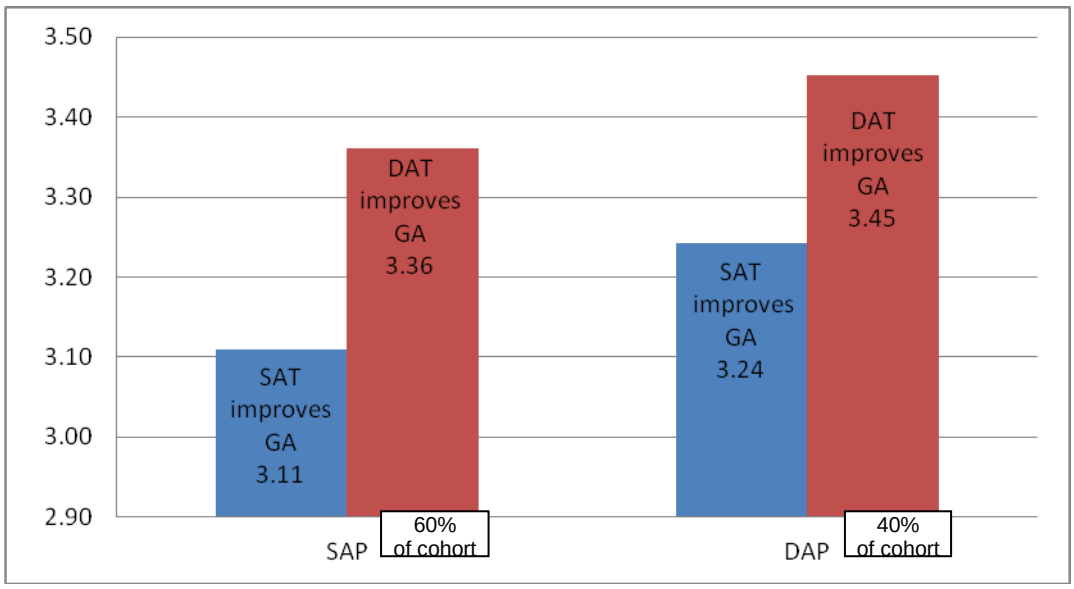

Figure 1: Relationship between assessment preference and increase in graduate attributes

Figure 2 further demonstrates the findings presented in Figure 1, and that is that the various learning approach and assessment combinations *all* agree that DAT (i.e. critical and deep thinking assessment) improve one's graduate attributes more than SAT (i.e. rote learning types of assessment). This has long been acknowledged by engineering educators but this study confirms that students' also acknowledge this very early in their engineering program. However, we need to understand why many students still adopt surface level approaches to learning and prefer surface assessment, when such educational approaches are not leveraging the best engineering graduate attributes. From Figure 2, it is evident that students having SLA in any combination had a lower degree of appreciation for any type of assessment improving their graduate attributes.

Essentially, student approaches and preferences are having some influence on curriculum design, which in-turn is reducing its amount of DAT. However, the short-term benefits of completing SAT means that student's are missing out on having better graduate attributes than if they engaged with DAT throughout their entire engineering program. This is reducing the competency and innovativeness of Australian engineering graduates. Reasons for

students preferences for SLA and SAP, even knowing that DAT improves their engineering career readiness, may be driven by the current student higher learning macro context. Some reasons for such a preference include:

- The secondary school system and the early years of engineering programs do not have a high degree of DAT, instilling preferences for SLA and SAP;
- Students working long hours in casual employment while completing full-time higher education promotes their desire for straightforward course assessment tasks that are not open-ended and requiring exploration and/or teamwork; and
- The University student evaluation surveys promote student satisfaction and not engineering graduate attributes thereby driving academics to provide SAT to students in order to satisfy their SAP.

The challenge for engineering educators and the profession at large is to build and/or maintain degree curricula that leads to achieving strong graduate attributes in the face of growing pressure to implement the often preferred shallow assessment types.

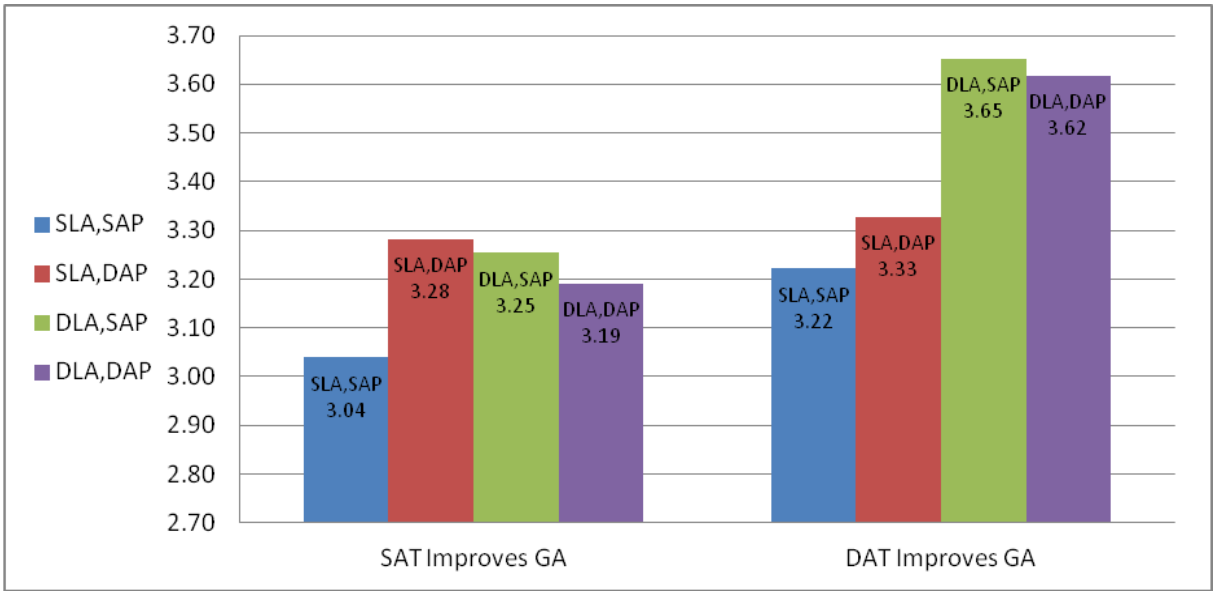

Figure 2: Student learning/assessment preference combinations and their appreciation of assessment type relationship with graduate attributes

Conclusion

The findings reveal that engineering students acknowledge that instilling deep learning skills is essential to be an effective engineering graduate that is embraced by industry. However, many second year engineering students still have a short-term focused preference for assessment that is highly defined. Furnishing empirical evidence on this mismatch is the first step to acknowledging this issue. The study indicates that Engineering Schools need to work with high schools to encourage deeper learning and continue to foster this style of learning at the outset of the engineering program to ensure that short-term goal orientated learning approaches do not become entrenched.

Further planned investigations will assist to determine if and how assessment preference changes as a student progresses through the engineering degree. Further questions to be investigated within the research include whether the results presented herein can be replicated from year to year; and whether students develop a deeper assessment preference as they progress through an engineering degree. Whether these findings can assist in the development of courses and assessment in general is also a question for investigation.

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