Assessing students’ perception of self as a learner

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Introduction

University programs strive to improve both student understanding and student attitude over the course of their studies. A substantial amount of effort is placed in developing and assessing the former, with the development tending to focus on educational innovations and use of technology in order to more effectively transfer knowledge to students and develop deeper levels of understanding. Subject final results serve as a basic but crude assessment, or indicator, of student learning, but without a benchmark indicator at the commencement of the subject it is difficult to measure the true gain in understanding. More meaningful measures of improvements in student learning can be obtained through evaluating the efficacy of particular teaching and learning interventions through pre- and post-testing of students.

The story is far different in terms of assessing and improving student attitude. Measuring student ‘attitude’ is typically performed post-semester, through a Subject Experience Survey (SES) that treats it as a simple, one-dimensional construct formed by answering a few carefully constructed survey questions on teaching and learning. Questions on such surveys typically include “this subject was well-taught” and “the teaching and learning activities improved my understanding of the subject material” and students must indicate their agreement via selecting a response ranging from “strongly disagree” to “strongly agree”. The scores for each question are averaged across the cohort to become a single numerical result. Clearly, reducing the information content in the data in this fashion prevents any reasonable statistical analysis to be performed, notwithstanding the fact that the questions as posed are inherently weak from a psychometric perspective. Indeed, many authors have pointed out this clear discrepancy over the years (Osborne, Simon, & Collins, 2003; Shrigley, Koballa Jr., & Simpson, 1988).

Another issue with assessing student ‘attitude’ through SES data in this lumped manner is that the ability to track changes over time and across sub-groups is severely limited. This has serious consequences for universities in terms of them being able to accurately measure student outcomes, such as the development of graduate attributes. Furthermore, as SES data are anonymous, pre- and post-assessment is not possible and there is no control group that can answer the survey questions for comparative purposes.

This study aims to overcome the shortcomings in traditional SES-style approaches to measuring student attitudes by creating a survey instrument that assesses student attitude through measuring students’ perception of self as a learner, with a focus on Electrical and Electronic Engineering. The structure of the survey includes several, multiple-item subscales that are psychometrically distinct yet have strong internal consistency and permits the tracking of students over the course of their degree. The implementation of such a survey has permitted building a more complete picture of student attitudes amongst a commencing student cohort, who for the institution considered in this study, come from increasingly diverse backgrounds.

Background

Self-concept, a hypothetical construct, is a cognitive evaluation that an individual makes and customarily maintains with respect to themselves concerning their ability in a general or a specific area of knowledge (Gable, 1986; Shavelson, Hubner, & Stanton, 1976). Self-concept has been identified as a contributing component in expectancy models of motivation, which are based on the notion that individuals will choose, and persist in doing, a task if they have a reasonable expectation for success (Pintrich & Schunk, 1996). It is thus seen as a measure of students' perception of self as a learner and how amenable they are to conceptual change. In particular, much of the interest in self-concept and achievement relation stems from the belief that academic self-concept has motivational properties such that changes in academic self-concept will lead to changes in subsequent academic achievement (Marsh & Yeung, 1997).

Numerous instruments for assessing self-concept have been developed over the years that can be used with individuals from childhood through to late adulthood and have varying levels of psychometric soundness, the strength of their theoretical base, and utility in a variety of research and practice situations (Byrne, 1996). The Self-Description Questionnaire III (SDQIII) (Marsh & O'Neill, 1984) is one such instrument that was originally developed for assessing self-concept in high-school students. It has had extensive development since its inception with proven strong validity and reliability characteristics (Marsh, 1990; Marsh & Shavelson, 1985; Wylie, 1989). The SDQIII defines 13 factors (e.g. mathematics, verbal, academic, relations with peers, physical appearance) to measure self-concept that are assessed using a 136-item questionnaire. It is not tied to a specific domain, unlike many self-concept instruments, and as such was deemed to be an appropriate basis for developing an instrument to assess the self-concept of engineering students at The University of Melbourne.

Students commencing the Master of Engineering degree at The University of Melbourne are required to have completed a minimum three-year undergraduate degree from a recognised institution in a relevant discipline area and achieved a Weighted Average Mark (WAM) above a certain cut-off threshold. In addition, particularly for international students, there are English language requirements that must be satisfied. Even with these entry requirements, due to the large amount of three- or four-year undergraduate science and engineering degrees offered across the world, students who are admitted into the Master of Engineering degree come from a wide variety of backgrounds – both in terms of their discipline knowledge and exposure to generic skills development such as problem solving and communication skills. It is therefore important to capture their initial state, in terms of attitudes, upon entry into the Master of Engineering. Having a more complete understanding of the cohort as a whole means that any necessary actions can be performed to change attitudes that may hinder their study or are not congruent with the University's broader Graduate Attributes. Furthermore, being able to track students' attitudes over the course of their studies provides a measure of how they are being developed.

Survey Development

In order to assess the students' self-concept, or perception of self as a learner, a survey called the Electrical and Electronic Engineering Self-Concept Inventory (EEE-SCI) was developed based on the SDQIII. Three of the factors from the SDQIII deemed most appropriate for understanding self-concept with respect to commencing Master of Engineering (Electrical) students were selected to be measured: Mathematics, Academic and Creativity / Problem Solving. Ten items were taken from the SDQIII for each of these three factors. Another ten items were created by modifying items representing the Verbal factor to more broadly cover Communication Skills, involving both written and verbal communication which are both essential for engineering students. Finally, ten items pertaining to Electrical Engineering were created by modifying several of the Mathematics items. All up, there were a total of fifty items for the EEE-SCI, spread across five factors, with ten items per factor. Given the number of students that would be taking the survey and the time available to complete it, this was deemed the upper limit to the number of items. The fifty items were placed on the survey as statements in a pattern similar to that of the SDQIII – every fifth item belongs to the same subscale, as shown in Table 1, and items are randomly distributed by direction (positive or negative). Table 2 illustrates this by listing an example statement from each factor.

Table 1: Survey item numbers and their factors

Factor	Items
Mathematics	1, 6, 11, 16, 21, 26, 31, 36, 41, 46
Academic	2, 7, 12, 17, 22, 27, 32, 37, 42, 47
Creativity / Problem Solving	3, 8, 13, 18, 23, 28, 33, 38, 43, 48
Electrical Engineering	4, 9, 14, 19, 24, 29, 34, 39, 44, 49
Communication Skills	5, 10, 15, 20, 25, 30, 35, 40, 45, 50

Table 2: Example items from each factor

Factor	Item
Mathematics	Q11. I have generally done better in maths subjects than in other subjects.
Academic	Q12. I like most academic subjects.
Creativity / Problem Solving	Q33. I am not very original in my ideas, thoughts, and actions.
Electrical Engineering	Q14. I find electrical engineering concepts interesting and challenging.
Communication Skills	Q50. I have good reading comprehension.

A survey form was generated that asked students to rate how accurately each statement described themselves and provided a seven-point scale ranging from “very inaccurate” to “very accurate” to do so; seven choices help strengthen the reliability of the instrument and allow greater distinctions between responses (Gable, 1986). The form had a section for optionally entering a student number and was designed in such a way that a machine could process the data accurately and quickly.

Results

The EEE-SCI was administered to commencing Master of Engineering students that attended a course information and welcome session. Students were given approximately 15 minutes to complete the questionnaire under exam-like conditions. Three semesters’ worth of commencing student data, over an 18-month period and totalling 151 completed questionnaires, was obtained and analysed. There were 4 surveys that were incomplete. The five most accurate and five least accurate statements, measured by the means of the item responses, are given in Table 3.

These results are largely to be expected as students entering the Master of Engineering (Electrical) degree are motivated and high-achieving students, who are passionate about Electrical Engineering and generally have well-developed mathematical skills. One interesting observation to be made, however, is the apparent tension between Q13 and the other four most accurate statements, which seems to indicate that while students enjoy working out new ways of solving problems and have a strong work ethic, they strongly feel as though they do not have enough imagination and creativity. Additionally, Q13 had one of the largest standard deviations of all of the items. This might imply that there are different sub-groups of students who respond quite differently to this statement.

Table 3: EEE-SCI items with strongest responses

Most accurate statements	**Mean**	**Std. Dev**
Q14. I find electrical engineering concepts interesting and challenging.	5.75	1.03
Q18. I enjoy working out new ways of solving problems.	5.64	1.22
Q2. I enjoy doing work for most academic subjects.	5.27	1.15
Q28. I have a lot of intellectual curiosity.	5.26	1.09
Q13. I wish I had more imagination and creativity.	5.20	1.47
Least accurate statements	**Mean**	**Std. Dev**
Q37. I hate most academic subjects.	2.01	1.08
Q4. I have never been excited about electrical engineering.	2.10	1.24
Q49. I have trouble understanding anything based on electrical engineering.	2.23	1.11
Q45. In school I had more trouble learning to read than most other students.	2.30	1.23
Q26. I have trouble understanding anything based on maths.	2.31	1.15

Statistical analysis, in particular *exploratory factor analysis*, was used to determine the survey items that seemed to belong together because of the similarity in patterns of responses by students (Fabrigar, Wegener, MacCallum, & Strahan, 1999). Each group of similar items then defines what is considered a ‘factor’ and can be combined into a *subscale*. Items on the EEE-SCI that had a negative direction were inverted on the scale. The procedure does not provide a black and white categorisation. It is necessary to run several analyses each with different constraints, and then to evaluate the results for interpretability. A more detailed discussion of the procedures available and the decision making process involved can be found in standard texts (Gorsuch, 1983). All statistical evaluation was performed using IBM’s SPSS software package, version 25.

The matrix of simple correlations among the EEE-SCI items contained a large number of values in the midrange (0.3 to 0.7), indicating the likelihood that the data set would likely factor well. To formally assess this, the Kaiser–Meyer–Olin (KMO) measure of sampling adequacy, which compares observed correlation coefficients with partial correlation coefficients, was calculated as 0.82. Kaiser (1974) recommends a minimum barely acceptable KMO value of 0.5, values between 0.7-0.8 as acceptable, and values above 0.9 as superb.

Factors were extracted using the *principal components analysis* method. A scree plot of eigenvalues and observation of the amount of variance explained by each one indicated between 5-6 strong factors. There was a clear break observed in the scree plot between the sixth and seventh eigenvalues, indicating a sensible choice of six factors to extract. Structure was explored by extracting the six factors using varimax (orthogonal) rotation and studying the pattern and magnitude of the loading (degree of association) of each survey item on each factor. The six extracted factors explained 53.12% of the variance in the data set. The high degree of relatedness of the items within each factor permit the scores of these items to be combined into a single *subscale score*, shown in Table 4. For instance, General Academic self-concept for one student consists of the sum of the values for items 2, 9, 12, 14, 27 and

37. Four of the items, with loadings between 0.299 and 0.340, had no strong association with any factor and were not included in the subscale calculations.

Table 4: Subscales identified on the EEE-SCI and corresponding item numbers

***Bolded item numbers indicate a different subscale to the instrument factor**

Subscale	**Item**
Mathematics	1, 6, 11, 16, 21, 31, 36, 41, 46
Electrical Engineering	4, **17**, **20**, **23**, 24, **26**, 29, 39, 44, 49
Communication Skills	5, 10, 15, **22,** 25, 30, 40, 50
General Academic	2, **9**, 12, **14**, 27, 37
Creativity / Problem Solving	3, 8, 18, **19**, 28, 33, 38, 43
Academic Concern	**7, 34, 35, 45, 47**

Some observations about the formation of the subscales:

- Creativity and Problem Solving were identified in the one subscale with an additional item, *Q19. I can relate topics in my other subjects to my electrical engineering knowledge*, which may indicate that students are using creative ways to relate the topics they encounter to their other subjects;
- The Electrical Engineering subscale included several items from the Mathematics, Academic and Problem Solving instrument factors;
- While *Q23. I'm not much good at problem solving* was grouped on the Electrical Engineering subscale due to it having the largest weighting, it also had significant weightings on the Communications and Creativity / Problem solving subscales.
- A sixth factor that emerged, termed the Academic Concern subscale, which comprises of the statements given in Table 5 – statements representing two factors from Communication Skills, two from Academic and one from Electrical Engineering. This could be perceived as measuring students' self-concept in concern in their academic abilities due to their breadth and the fact all are negatively posed.

Table 5: Statements corresponding to the Academic Concern subscale and their loadings

Statement	**Subscale Loading**
Q34. Engineering intimidates me.	0.600
Q7. I hate studying many academic subjects.	0.590
Q35. I often have to read things several times before I understand them.	0.504
Q47. I could never achieve academic honours, even if I worked harder.	0.470
Q45. In school I had more trouble learning to read than most other students.	0.442

Subscale scores may also be calculated as an average of the item ratings, given as a normalised range between 0 and 1 (representing the instrument range 1–7) and shown in Table 6. It is noted that the two weakest self-concepts identified were Mathematics and Communication Skills, which seems to agree with anecdotal evidence from teaching staff.

Internal consistency, or the relationship of the items in a subscale to each other, was determined as a measure of reliability. A statistic typically used is Cronbach's α, which is based on the average correlation of items and is also shown in Table 6. Typically, values above 0.7 are deemed acceptable (Kline, 2000), with Academic Concern the only value below 0.7.

Table 6: Normalised self-concept scores and reliability estimates across subscales

Subscale (self-concept)	Normlised Score	Cronbach's α value
Mathematics	0.67	0.73
Electrical Engineering	0.75	0.81
Communication Skills	0.65	0.85
General Academic	0.76	0.78
Creativity / Problem Solving	0.74	0.76
Academic Concern	0.72	0.65

Discussion

Most subscales were relatively aligned with the original survey instrument factors, with the two weakest normalised scores being for the Mathematics and Communication Skills subscales, shown in Table 6. This result could indicate the need for additional testing of students' knowledge in mathematics in the form of an entry exam or concept inventory to see if it corresponds to a deficiency in technical knowledge. For Communication Skills, this may represent a combination of a couple of causes: (1) the underexposure of engineering students to opportunities for developing their communication skills and (2) the large proportion of lateral entry students that are international students who might perceive their English skills to be insufficient. The additional subscale that was identified, Academic Concern, appears to represent items that reflect concern in academic ability across multiple factors. All items in this subscale were negatively worded, which may indicate that a response set effect has contributed to the distinctness of these items. Its self-concept score, in Table 6, is on par with Electrical Engineering and General Academic and could indicate the need for providing additional academic support services for students. Finally, students did not appear to differentiate between Problem Solving and Creativity, with the identified subscale being a combination of both as in the original SDQIII questionnaire.

Validity of the EEE-SCI could be performed by having students resit it shortly after completing it for the first time, however it was not possible to have them be present in the one location again due to the commencement of the semester. Validity could also be evaluated by comparing instrument subscale scores with student subject performance, which requires collating student result data and will be the subject of future work.

While the results appear to agree well with anecdotal evidence of students' perception of their skills, more survey responses may be needed in order to provide stronger verification. There are differing views on the number of responses per survey item required, for example, Gorsuch (1983) suggests 5 responses per item.

The EEE-SCI was designed to serve two purposes: (1) provide an initial 'snapshot' of student attitudes, as measured by self-concept, for those entering the Master of Engineering (Electrical) degree and (2) to track the evolution of their attitudes. With respect to the latter, it is envisaged to administer the EEE-SCI again as students complete their degree with the view to aid in curriculum and program development in the future.

Conclusion

Several subscales were identified from the EEE-SCI that provided a picture of the cohort of commencing Master of Engineering students in terms of their perception of self as a learner, or self-concept. While most subscales were closely related to the instrument factors, a sixth could be seen as measuring Academic Concern across multiple factors. Further research is expected to be performed by analysing the differences in item responses with various subgroups of students and future work will involve having students retake the EEE-SCI at the end of their degree to observe any patterns of change in their attitudes over time.

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