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Validity Of Student Professional Practice Competency Claims

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VALIDITY OF STUDENT PROFESSIONAL PRACTICE COMPETENCY CLAIMS

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ABSTRACT

The University of Sydney has introduced a program of engaging engineering students throughout their degree program in diverse forms of self-selected exposure to, and engagement with, professional practice. To gain recognition of completed activities students are required to submit "claims" that include identification of the core competencies that were developed and demonstrated during the activity, along with a detailed reflection on their learning. Given that the claims are highly individualised and often unsupervised, assessment is predominantly limited to evaluation of the reflections along with evidence of the activity. A key question in the program relates to the validity of the assertions made by student regarding the competencies that have been demonstrated. In this paper we report on an analysis that compares student claims regarding competencies that were developed with the language contained within their reflections, and the extent to which those reflections focused on the competencies specifically being claimed. The results suggest that for claims related to some competencies, such as team skills, the student reflections do indeed tend to include a stronger focus on that competency. Conversely, for other competencies, such as understanding of the underpinning sciences and engineering fundamentals, the reflections are much less clearly connected to the competency. This may be the result of greater diversity of understanding, but we also consider the possibility that it may relate to less clarity by students regarding the language used in reflecting on these competencies, and the implications of this for the development of their understanding.

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1 INTRODUCTION

1.1 General Context

A long-standing consideration within Engineering degree programs has been the role of student connections to professional practice. A key argument (particularly in many accreditation processes) is that exposure to, or engagement with, professional practice as a core element of degree programs is an important mechanism for developing professional competencies, and for integrating these competencies with the more technical capabilities that are developed.

Opportunities to strengthen educational outcomes associated with exposure to professional practice, as well as growing challenges in obtaining high quality internship experiences for students has led to a growing interest in alternative approaches to providing students with exposure to professional practice. In 2018, The University of Sydney introduced a novel professional engagement program for all new undergraduate engineering students. Throughout their degree program students are required to select and complete a wide range of both in-curricula and extra-curricular activities, with these activities scaffolded through a series of workshops. For each completed activity they must submit a “claim” that involves a detailed reflection as well as report on the professional competencies that they demonstrated. The result is a very large collection of student activity reflections (currently exceeding 12,200 reflections on extra-curricular activities, averaging approximately 400 words per reflection). These reflections provide a rich source of information on student reactions to, and understanding of, the nature of practice. The students also have access to a reporting dashboard (see Figure 1) that provides them with a summary of the number of hours of activities they have successfully completed as well as the balance across different competencies.

It is important that understand whether student claims regarding individual competencies are likely to be valid. A first step in exploring this question of validity is to look at the extent to which the student reflections are focused on the competency being claimed. In this paper we therefore report an analysis of student reflections. We identify the various engineering competencies that are being considered and how these relate to the specific claims being made by students in terms of the competencies that were the focus of their activities.

1.2 Exposure to Professional Practice

Numerous reviews into Engineering education have recognised the need for engineering students to develop broader professional skills in addition to technical skills development (e.g. Graham 2012; National Academy of Engineering 2004). Historically, one of the key approaches used in supporting the development of these broader skills, as well as integrating the various competencies into a holistic whole, has been the use of exposure to, or indeed engagement with, professional practice during undergraduate studies (Ryan et al. 1996). This recognition of the value of engagement with professional practice is so deeply recognised that it has become embedded in many accreditation frameworks (ABET 2011; Engineers Australia 2013; UK Engineering Council 2014).

A key challenge in managing exposure to practice programs has been the question of how student activities can be assessed. A range of characteristics of these programs make assessment somewhat challenging, for example: the diversity of the experiences and hence outcomes; the individual nature of student involvement; and the qualitative character of many of the competencies that form the focus of development. Due to these challenges it is common to rely on student self-assessment of their outcomes – requiring students to reflect upon their experiences and evaluate their learning outcomes.

1.3 Student Self-Assessment

There is a considerable body of research that explores both reliability (i.e. consistency across time, student, activity etc.) and validity (i.e. are we measuring what we believe we are) of student self-assessment. Cassidy (2007) explores self-assessment in the particular context of inexperienced students (which will often be the case in engineering programs), arguing that "findings suggest that while self-

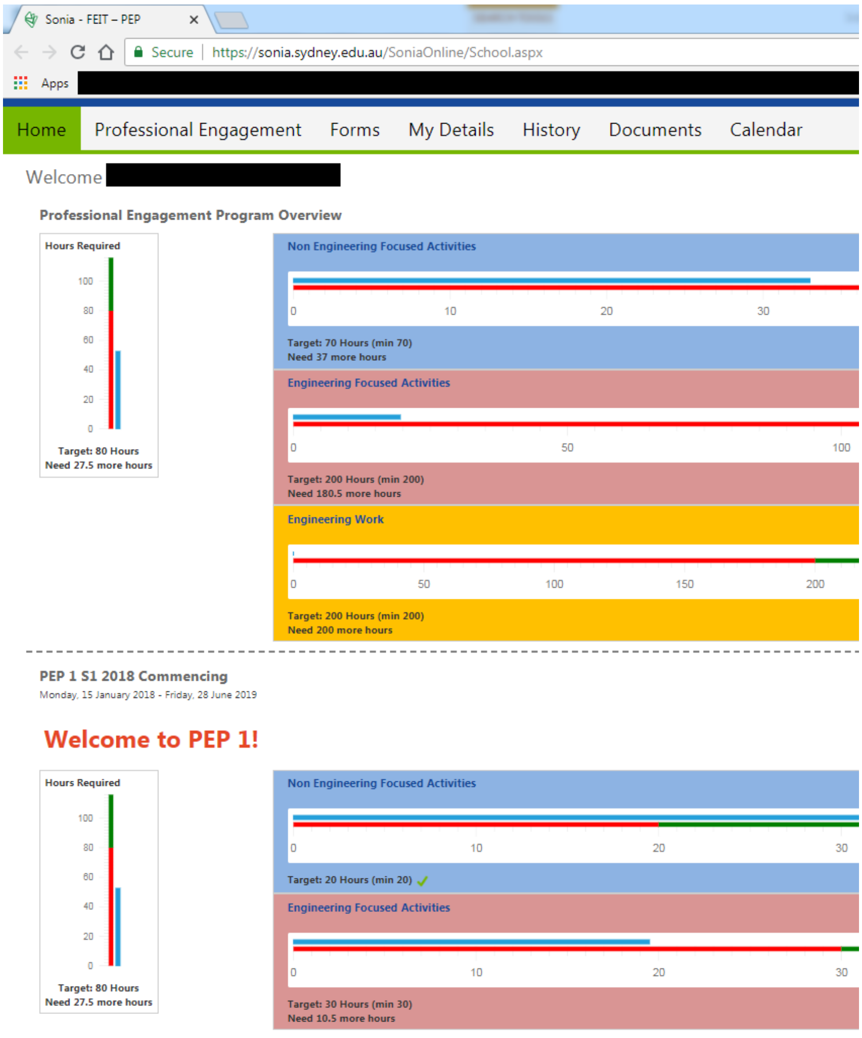

Figure 1: Professional Engagement Program: Student Dashboard

assessment skill undoubtedly develop, becoming more effective during students' academic career, inexperienced students do have the capacity for self-evaluation". It is noted in this study however that this is a significant minority of students for whom self-assessment is problematic. Another interesting study in this area (Baxter & Norman 2011) notes that there is significant doubt about students' self-assessment ability but makes a useful distinction between perception of self-assessment capability and actual reliability of self-assessment.

Whilst the above studies focused in specific (often technical) skills, another study (Chan et al. 2017) focused on students' perceptions of competency in generic skills and in the engineering domain. Essentially this study was aiming to understand students' motivations to develop generic skills by investigating their perceived level of self-competence. Unfortunately, this study was relatively narrow and only considered students perceptions of their competence, and not how this related to actual competence. It is useful however insofar as it suggests student typically perceive that their technical competence is lower than their generic skills!

Other similar studies (Donnon et al. 2013; Falchikov & Boud 1989; Ross 2006) continue the pattern that the level of both reliability and validity of students' self-assessment tends to vary significantly depending upon a wide range of factors: student experience; level of knowledge; domain of knowledge; discipline area; and especially the level of training in how to undertake a self-assessment.

One relatively common pattern in the literature, particularly regarding support for effective self-assessment, is the use of student reflection. This is particularly significant in the context of encouraging a more critical analysis by the students, and hence an increase in validity of the outcomes. Student reflection is, however, only likely to be most effective is the reflections relate to the competencies that are the focus of self-assessment. It is this issue that is the focus of this paper: exploring the extent to which students undertaking self-assessments of selected competencies are reflecting on aspects that do relate to those competencies.

The Professional Engagement Program (PEP) at the University of Sydney provides a useful source of data in exploring this question. This is especially true given two key characteristics of PEP: (1) the deep integration of both student reflections and self-identification of competencies that have been developed; and (2) the very substantial diversity of student professional engagement activities that are undertaken, and hence the opportunity for developing very diverse competencies.

2 METHODOLOGY

The Professional Engagement Program commenced in the 2018 academic year. Subsequently, students submitted numerous activity claims. Certain types of claims required student to both submit a reflection on the activity and to identify up to three competencies that were demonstrated through that activity. A data extract was taken from the online claim system and the data was then cleaned (to remove claims without reflections, that had not yet been assessed, or had been assessed as inadequate). The identified competencies were then matched back to the reflections (these are stored separately in the system) resulting in N=2,368 pairs of demonstrated competency and reflection.

The reflections contained an average of 411 words per reflection in each claim. (This resulted in close to a million words of reflection across the claims being considered). The following is an extract from a typical reflection:

> *"I undertook this activity as I thought it would be an excellent opportunity to develop my skills in engineering whilst also enhancing my abilities to work with a team of strangers […] Initially, being one of the more junior members of the group, I felt apprehensive engaging in group discussions and planning as I was unsure of my ability to actively contribute something useful. However, as I became more comfortable with my group members and our task I began to open up and suggest ideas […] one thing that I learnt the most from this experience was the importance of voicing opinions during the design, planning and construction of a project".*

These reflections were then imported into NVivo and a thematic coding was carried out. Each reflection was coded against each of the sixteen Engineers Australia Stage 1 competencies (Engineers Australia 2013) – see Table 1. A fully manual thematic coding was impractical given the volume of content, but the nature of the content (i.e. reflections of practical experiences that followed relatively similar patterns of activity, with reflections structured against a common professional competency framework) made an auto-coding approach feasible (see (Guest et al. 2012) for a discussion of this can be carried out). Each reflection was auto-coded by searching for the existence of key verbs associated with each competency. The key verbs were drawn from descriptions of the competencies within a range of professional frameworks. A random sample of the coded reflections (N=50) was then assessed to ensure that there were no systematic errors being introduced.

Table 1. Summary of Engineers Australia Stage 1 competencies. See (Engineers Australia, 2013) for full details.

1. KNOWLEDGE AND SKILL BASE	
1.1.	**Comprehensive, theory based understanding** of the underpinning natural and physical sciences …
1.2.	**Conceptual understanding** of underpinning mathematics and information sciences.
1.3.	**In-depth understanding** of specialist bodies of knowledge within the engineering discipline.
1.4.	**Discernment** of knowledge development and research directions within the engineering discipline.
1.5.	**Knowledge** of engineering design practice and contextual factors impacting the engineering discipline.
1.6.	**Understanding** of the scope, etc. of sustainable engineering practice in the specific discipline.
2. ENGINEERING APPLICATION ABILITY	
2.1.	**Application** of established engineering methods to complex engineering problem solving.
2.2.	**Fluent application** of engineering techniques, tools and resources.
2.3.	**Application** of systematic engineering synthesis and design processes.
2.4.	**Application** of systematic approaches to the conduct and management of engineering projects.
3. PROFESSIONAL AND PERSONAL ATTRIBUTES	
3.1.	**Ethical** conduct and professional accountability.
3.2.	**Effective** oral and written communication in professional and lay domains.
3.3.	**Creative**, innovative and pro-active demeanour.
3.4.	**Professional** use and management of information.
3.5.	**Orderly** management of self, and professional conduct.
3.6.	**Effective** team membership and team leadership.

For each unique valid reflection, we calculated the total number of words in the reflection, along with the number of occurrences of the verbs associated with each competency. Dividing the latter into the former provided a “verb density” for each competency in each reflection. Given that these densities would depend upon the overall choice of verbs used, a direct comparison between densities for each competency was not appropriate. Instead the densities were then converted into z-scores for that competency.

For example, consider competency 1.5 (knowledge of engineering design). This had an average density of related words of 0.54% of all words, and a standard deviation of 0.81%. An example claim with a lower than average proportion of words related to knowledge of design had a word density of 0.27%, and hence a z-score of -0.37. Conversely, a different claim had a higher proportion with a word density of 1.76% and a z-score of +1.45.

For each claim, the competencies were put in order from highest to lowest z-score. This meant that if a given reflection discussed a particular competency much more than the average for that competency, then it would have a high z-score for that competency and so would be rated highly and vice versa. These ratings were then compiled for all competencies, and the results collated. This approach allowed us to explore the extent to which students who asserted that a particular activity allowed them develop a given competency then actively reflected upon that competency within their associated reflections. Further, we could compare these patterns across different competencies, and especially to see whether any patterns emerged.

3 RESULTS

Table 2 shows the resultant average z-scores for the verbs associated with each competency in the reflections. Each row represents the set of activity claims where the students have asserted that they developed each specified competency. For example, the final row represents all the claims where the students said they developed competency 3.6 (effective team membership and team leadership). In this row you can see that on average the associated reflections had a z-score of 1.03 for verbs associated with that competency– i.e. just over one-standard deviation above the average for all reflections – suggesting that, on average, students who claimed that they developed team skills during the activity, did indeed discuss team skills in their reflections significantly more than average. You can also see other insights from this data. For example, students who claimed that they developed competency 2.3 (application of systematic synthesis and design processes) also discussed teamwork (competency 3.6) somewhat more than average, with a z-score of 0.54.

Analysing this data, and in particular looking at the outliers, allows several quite interesting insights to emerge. Firstly, considering Table 2, we can see that the claims associated with every one of the competencies contained reflections with an above average density of verbs related to the competency being claimed. This suggests that on average students are indeed making an attempt to reflect on the

Table 2. Average z-score for verbs associated with each competency in student reflections (with outliers shown highlighted)

		Competency referred to in reflections															
	Comp	**1.1z**	**1.2z**	**1.3z**	**1.4z**	**1.5z**	**1.6z**	**2.1z**	**2.2z**	**2.3z**	**2.4z**	**3.1z**	**3.2z**	**3.3z**	**3.4z**	**3.5z**	**3.6z**
Competency claimed	1.1	0.31	0.31	0.72	0.29	0.08	0.38	-0.15	0.23	0.17	-0.18	0.36	-0.22	-0.14	0.23	-0.09	-0.37
	1.2	0.38	1.01	-0.11	0.13	-0.11	0.99	0.30	0.02	-0.12	-0.17	-0.06	-0.28	0.24	0.64	0.32	-0.30
	1.3	0.37	0.16	0.56	0.08	0.08	0.02	-0.08	0.22	0.00	-0.18	-0.11	-0.14	-0.02	0.03	0.09	-0.29
	1.4	-0.15	-0.21	0.99	0.68	0.06	-0.12	-0.24	-0.18	0.04	-0.13	-0.17	0.05	-0.20	0.13	-0.20	-0.35
	1.5	0.02	0.08	0.08	0.20	1.01	0.05	0.22	0.40	0.94	0.18	-0.08	-0.15	0.02	-0.02	-0.11	-0.08
	1.6	0.01	-0.14	0.43	0.27	0.63	1.00	0.04	0.16	0.18	0.03	0.06	-0.08	0.17	0.04	-0.11	-0.27
	2.1	0.19	-0.09	0.09	0.05	0.31	0.32	1.27	0.24	0.76	0.25	-0.13	-0.40	0.39	-0.07	-0.13	-0.07
	2.2	-0.06	0.59	0.05	-0.02	0.24	0.53	0.00	0.55	0.17	0.14	-0.10	-0.27	-0.02	0.05	-0.02	-0.24
	2.3	-0.11	0.15	-0.24	0.23	0.95	0.17	0.76	0.57	1.17	0.43	-0.09	0.01	-0.04	-0.36	-0.19	0.54
	2.4	0.08	-0.19	0.01	-0.08	0.37	-0.05	0.00	0.03	0.23	1.56	0.03	-0.08	-0.16	-0.18	-0.09	0.52
	3.1	0.12	-0.18	-0.15	-0.02	-0.01	0.70	-0.27	-0.01	-0.27	-0.19	1.37	-0.16	-0.06	-0.01	0.08	-0.23
	3.2	-0.12	-0.19	-0.19	-0.03	-0.23	-0.23	-0.15	-0.14	-0.26	-0.27	-0.07	0.75	-0.14	0.03	-0.05	-0.23
	3.3	-0.02	-0.15	0.09	-0.09	-0.14	-0.26	0.02	-0.07	-0.03	-0.20	-0.08	-0.35	0.19	-0.12	0.02	-0.26
	3.4	0.12	0.15	-0.03	0.28	-0.26	-0.05	-0.15	0.12	-0.24	-0.08	-0.19	-0.04	-0.17	0.92	-0.06	-0.37
	3.5	-0.17	-0.28	-0.23	-0.04	-0.28	-0.19	-0.10	-0.19	-0.31	0.00	-0.05	-0.13	-0.08	-0.10	0.32	-0.26
	3.6	-0.04	-0.23	-0.25	-0.28	-0.23	-0.22	-0.03	-0.14	-0.25	0.01	-0.04	0.01	-0.06	-0.23	-0.07	1.03

competencies that they are claiming. It is interesting to note though that the average levels did vary significantly. For example, for claims associated with competency 2.4 (conduct and management of projects), the reflections had a z-score for that competency of +1.56, suggesting a strong relevant focus in the reflections. Conversely, competency 3.3 (creative and pro-active demeanour) had reflections with a z-score for that competency of only +0.19, suggesting that the focus was only a little above the average.

Drilling further into the details of the analysis, we also found that the extent of variation between individual claims depended on the specific competency being claimed. The competencies which had the highest proportion of claims with reflections focused on the competency included: 1.4 (knowledge development), 2.1 (complex problem solving), 2.4 (management of projects), 3.2 (communication) and 3.6 (teamwork). Conversely, the competencies which had the lowest proportion of claims with relevant reflections included: 1.1 (underpinning sciences), 1.2 (mathematics), 2.2 (application of tools and techniques), 3.1 (ethical conduct) and 3.3 (creative and pro-active demeanour).

Comparing these two sets of competencies reveals a possible explanation. The first set may tend to be associated with elements where the students are likely to have a solid grasp of the language associated with the competency. The latter set may relate to competencies where the students lack a grasp of the language associated that competency – making it more difficult for them to construct effective reflections. For example, whilst they are likely to have significant exposure to the language of communication and teamwork, the same may not be true of the language of ethical conduct. If this observation is indeed correct, then this suggests that there may well be a problematic cycle at play: students don’t have the language to reflect effectively on selected competencies, and hence they choose not to, and so their depth of understanding in that area remains unsupported by effective reflection.

Another interesting pattern can be seen with competency 3.5 (self-management and professional conduct). With this competency, just over 50% of the claims had reflections with a z-score ranked 1-4, suggesting that these students did discuss this competency in some detail. Somewhat surprisingly however there is 21% of the claims where the reflections had very little or no use of verbs associated with that competency (possibly because of a lack of understanding of the intent of this particular competency). A similar pattern, though not quite as pronounced, also occurs for competency 3.3 (creative and pro-active demeanour). One possible conclusion from this data is that there are certain competencies where the level of understanding is much more diverse, and so more care needs to be taken to ensure that certain students are not left behind.

And one final observation can be made from the data. There are interesting patterns of coupling between different competencies. For example, students who were claiming that their activity developed competency 2.3 (application of systematic synthesis and design processes) also had a higher than average likelihood of discussing 1.5 (knowledge of design practice). The reverse is also true. This particular coupling is not surprising given the inherent relationship between these two competencies. There are other couplings for which the reason is less obvious. For example, students who claimed that their activity developed competency 1.2 (mathematics) also had a higher than average likelihood of discussing 1.6 (sustainable practice), though interestingly the reverse is not true. The explanation for this is unclear but may relate to students struggling to reflect effectively upon their conceptual mathematics knowledge, and hence revert to reflecting upon much broader knowledge bases – and competency 1.6 may be somewhat of a catch-all.

4 SUMMARY AND ACKNOWLEDGMENTS

The findings described above have some important implications for educators. Firstly, as noted, it is likely that students are more likely to reflect effectively on the development of a claimed competency when they have clearly understood language skills related to that competency. This suggests that it is important not only to develop specific competencies, but to consider students' development of the language used to describe those competencies.

Another important implication arises from the evidence that there is much more significant variation in the nature of student reflections with regard to some competencies than with others. The greatest variations appeared to occur with competencies connected to student agency – e.g. 3.5 (self-management and professional conduct) and 3.3 (creative and pro-active demeanour). A key lesson from this is that to promote the development of these competencies, we should first address issues of student diversity and agency.

And finally, these results support the importance of providing guidance to students overall on reflective writing and how this relates to understanding their strengths with regard to different competencies. An interesting exercise worth exploring may be to provide students with a list of key verbs related to each competency and ask them to use them in the writing. Further work will also more explicitly focus on analysing the outliers identified in Table 2.

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