

## Exploring possible selves in a first-year physics foundation class: Engaging students by establishing relevance

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Students often complain that they cannot see the relevance of what they are being taught in foundation physics classes. While revising and adjusting the curriculum and teaching are important, this study suggests it might also be useful to help students view their learning in relation to their future career aspirations. This paper reports on a study conducted with first-year students enrolled in a compulsory foundation physics unit with a history of low pass rates. Working within a “possible selves” framework, activities were designed to help students position their learning in relation to possible future lives and careers. Two cohorts of students ( $N = 93$ ) engaged in an intensive workshop comprising multiple activities relating to self and career. Self-reflection worksheets were analyzed using content analysis. The results indicate that students experience immediate benefits from these activities through self-reflection on the current self, future possible professional selves, and the role of current studies in narrowing the gap between the two.

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### I. INTRODUCTION

Lower than average completion rates as reported in higher education science, technology, engineering, and mathematics (STEM) courses [1] highlight the need to find ways to motivate and engage students in these subjects. In this paper we explore “possible selves” [2] as a framework for engaging first-year university STEM students, the majority of whom are students in the emerging adulthood stage of development characterized by continued identity exploration [3,4]. The research contributes to an emerging discussion about appropriate on-going curricular interventions that foster healthy learner and professional identities in the discipline of physics.

We first provide a brief overview of identity formation during emerging adulthood, with a focus on the importance of career preview in motivating and engaging students [5]. We then outline a workshop designed within the possible selves framework with the aim of developing learners who position their learning in terms of its contribution to their future lives and careers. We present findings from the workshop across two cohorts of students in a foundational physics course, highlighting the immediate benefits of self-reflection on current selves

and future possible professional selves in emphasizing the importance of university studies.

#### A. First-year university students and the process of identity formation

The formation of identity throughout the period of emerging adulthood [3,4] is an important and often convoluted developmental process. As such, traditional-age university students are often experimenting with possible identities while simultaneously considering the lives and careers that might result from their chosen courses of study.

Shepard and Marshall [6] emphasize the need for young people to participate in life-career planning, and Beattie [7] argues that this should occur from the first year of study. Students’ ability to engage in such life-career planning develops alongside their formation of identity, with both requiring the adoption of future-oriented thinking. Unsurprisingly, students vary greatly in this respect with some students having given little thought about what the future might hold and others starting university with a career identity that is not open to exploration [8]. Both mindsets are problematic for educators seeking to engage students in developing a sense of purpose that relates to their studies and their future careers, particularly in disciplines where the graduate outcomes are less defined.

#### B. Career preview and relevance

Many science programs have poor graduate full-time employment rates and high levels of continued graduate

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study, reflecting disciplines for which there are few full-time positions at graduate level alongside those for which graduate study is a prerequisite to entry. Most Australian science graduates are understood to go on to work in a science-related area at a professional or management level [9]. Earlier research [10] with Australian science graduates from 1990 until the year 2000 reveals that almost half of science graduates obtain professional or managerial jobs within one year of graduation.

With the exception of geology graduates, however, science graduates are known to have above-average difficulty finding positions upon graduation [11]. Engineering graduates face similar difficulties, with only 60% of engineering graduates going on to work in engineering-related roles [12]. Similarly in the US, the majority (74%) of STEM graduates are employed outside STEM occupations [13].

Alongside this is the problematic issue of student attrition: for example, undergraduate engineering courses in Australia encounter attrition rates of 35% [14]. The situation is worse in the US, with over 60% attrition from STEM undergraduate degrees [15].

Graduate destinations in STEM highlight the need for students to make the link between their learning and their future lives and work at the levels of both unit and degree course (program).<sup>1</sup> Among the most difficult units in this respect are large, compulsory (core) foundation units within the first year of study.

Erikson [16] and Marcia [8] agree that adolescents are more likely to engage in learning when it is perceived as relevant to their future lives and work; however, when students enter university with a poor level of career preview this relevance has yet to be established. While students might develop an understanding of work and career (career preview) as they progress through their studies, this is rarely an explicit focus of higher education programs. Thus for generalist degree programs such as those in science, for which there are multiple and diverse graduate pathways, the development of career preview is crucial.

### C. Career preview and possible selves

Establishing the relevance of learning enables students to make vital connections between self, learning, and their intended field of work by seeing “the relevance of concepts, resituating the concepts and integrating new knowledge” [[17], p. 286]. Belief in the relevance of science to future careers is a strong predictor of motivation to learn for non-science majors studying science units [18].

Class discussion of currently relevant science and career expectations in high school are also significant predictors

of strength of physics identity in college students [19]. This is central to the transition from student to emerging professional, as observed by Bhattacharyya and Bodner [20] in their work with graduate chemistry students. In this sense, relevance is a significant factor in the development of identity. It is also central to motivation and engagement in that once students understand the relevance of learning they are known to refine their behavior in line with emerging strengths, interests, and aspirations [21].

Student aspirations can be thought of as achievement goals that prompt students to regulate their behavior in order to achieve those goals. Student aspirations are one of the most significant indicators of academic achievement [22], and this highlights the importance of encouraging future-oriented thinking and the exploration of future identities or selves.

Where much identity research is focused on antecedents to present identity, the possible selves framework [2] concerns the planning and implementation of strategies towards the realization or avoidance of possible future selves. This is particularly relevant to first-year students as they transition into higher education and begin to negotiate study pathways. Despite this, research to date on “possible science selves” [23] has focused on middle and high school students [19,24,25] rather than undergraduate students.

The possible selves approach aligns with the future orientation of higher education policy towards enhanced graduate employability. Acting as “an evaluative and interpretive context for the current view of self” [2], p. 962), in a higher education setting the possible selves framework can be employed to encourage students to plan towards realizing their future personas and exploring their career aspirations [26].

Actual and designated identities [27] are influenced by multiple factors including academic achievement, significant people in the lives of students, changes of circumstance, and education-related decisions such as those made prior to and during higher education. Arguably these factors also influence students’ ability to manage the transition into and through the first year of study.

In terms of transition, students are known to struggle with the different learning contexts experienced in school and higher education. Less discussed is that the difference between school and university schemas contributes to identity uncertainty [28] as students enter university with naïve, untested and decontextualized knowledge of university life and the expectations of study. Students’ expectations of foundation units such as those in physics are arguably even more naïve given the multiple major disciplines of participating students. In this sense it is unsurprising that “students may believe that physics is related to the real world in principle, but they may also believe that it has little or no relevance to their personal experience” [[29], p. 219].

<sup>1</sup>At the university where the study was conducted, degree programs are known as courses. Elements of a degree program, known as courses or modules elsewhere, are known as units. Higher education in Australia relates to postsecondary (tertiary) study.

Scanlon *et al.* [30] contend that students who do not have the “ways of knowing, writing and valuing esteemed by the university” will find the new schema more difficult to negotiate, and it is likely that this cultural capital [31] is more established in higher socio-economic students who are not the first in their family to attend university. This may compound the impact of other differences between first-in-family and “traditional” students, such as fewer family resources, lower academic achievement, less rigorous academic courses prior to entering university, and lower confidence in their academic ability (see Ref. [32] for a recent review). Further, the cultural mismatch between interdependence background norms of first-in-family students and the independence expectations of universities also affects the academic progress of first-in-family students [33]. This was a particular concern for this study, which was conducted at the university with the highest proportion of low socioeconomic students in Western Australia (23.8% of all undergraduate students) [34].

## II. CONTEXT

The context for the current study was a first-year foundational unit in physics at an Australian university. The unit, *Principles of Physics*, is a calculus-level physics unit that provides students with the basic skills in physics needed for their degree programs. Students taking the unit come from several different disciplines and the unit as a whole has a significant failure or withdrawal rate, thought to be due to low student engagement. Low completion rates in first-year physics are not a unique problem and the difficulty of engaging nonphysics students in physics has been experienced by universities across Australia [35] and internationally. Indeed, science, technology, engineering, and mathematics (STEM) disciplines all experience lower completion rates than do other disciplines [1]. Across STEM disciplines contributing predictive factors include demographic factors, poor precollege or university academic preparation, and low socioeconomic status [36].

Prior to the current study, several approaches to learning and teaching had been trailed in an attempt to improve retention rates for this foundation unit. These approaches had yielded varying degrees of success, but concerns about the pass rate and student attrition remained. While many of the lessons from these earlier approaches had been embedded within the unit, it was noted that all of them focused on what the unit coordinator or lecturer could do to engage the students. This latest study focused on the students themselves, considering what might encourage them to keep going when learning gets difficult and time is limited.

Using a workshop approach and adopting the theoretical framework of possible selves [2], students were encouraged to consider their future lives and work. We hoped that the future orientation of possible selves might encourage students to take an active role in developing future selves and considering these in relation to their learning.

Reviews of possible selves literature [37,38] highlight the various research methods used to gather data relative to the future-oriented self-identities of research participants. Structured surveys are the most widely used data-gathering tools (see Ref. [2]), with narrative techniques and those requesting visual data becoming more common [39].

As part of the unit, students participated in a two-hour workshop. The workshop comprised a whole-class discussion on learning and relevance, an individual self-reflection with a focus on aspirations, a group discussion about the characteristics of a professional in the students’ discipline, an analysis of any perceived gaps between self and engineer, and future-oriented activities about goals and aspirations. Students also completed a group activity on teamwork and wrote a short reflective paper. The activities were designed to focus students’ thinking on self and career, and they were invited to submit their responses for analysis. The length of student responses ranged from short-response answers to paragraphs of text, depending on question and activity. This elicited multiple forms of data including individual reflections, discussion observations, and group responses.

It is proposed that students who can envision their future lives and careers may have a stronger motivation to continue to strive in their studies than those who do not. Therefore, the aim of this study was to develop learners who position their learning in this unit in terms of its contribution to their future lives and careers. In order to begin to assess this, we asked the following research questions:

- (1) How do students characterize a professional in their chosen field?
- (2) What differences do students perceive between themselves and their definition of a professional?
- (3) In what ways do students think that the learning in this unit might contribute to their development as a professional?
- (4) Do students perceive the possible selves workshop as transformational?

## III. METHODS

### A. Participants

The participants of the study were 93 students enrolled in a first-year physics unit at an Australian university in 2014. The first cohort (sample 1) comprises the 58 students (of 75 on-campus students enrolled; 79%) who attended the first workshop in first semester. The second cohort (sample 2) comprises the 35 students (of 58 on-campus students enrolled; 60%) who attended the first workshop in second semester. Students ranged in age from school leavers (aged between 17 and 18 in the Australian context) to students who had been in the workforce and were returning to university to further their education. The majority of students planned careers as engineering professionals or natural and physical science professionals (Table I).



TABLE I. Planned future careers of participants. Note that S = semester, Eng = engineer. Planned careers were grouped using the *Australian Classification of Occupations*, (Australian Bureau of Statistics, 1997).

Planned career	S1	S2	Total
<i>Natural and physical science professionals</i>	23	9	32
Academic or scientist	4		4
Biochemist	1		1
Environmental eng.	8	2	10
Renewable energy	2	3	5
Extractive metallurgist	5	2	7
Physics & nanotechnology	3	2	5
<i>Building or engineering professionals</i>	31	24	55
Electrical power eng.	8	5	13
Engineering technology	1		1
Chemistry	2	4	6
Chemical eng.	3	11	14
Metallurgical eng.	14	2	16
Instrument or control engineer	3	2	5
<i>Other Professionals</i>	4	2	6
Pharmacy		1	1
Teacher	2		0
Software engineer	1	1	2
Lab technician	1		1
Total	58	35	93

### B. Measures

A self-reflection worksheet asked the following questions:

- (1) Name 3 characteristics of your chosen profession (e.g., engineer, scientist, teacher)
- (2) What differences are there (if any) between you and the above?
- (3) What do you see as a role of a \_\_\_\_\_? (Insert your profession)
- (4) What will your personal role be?
- (5) How will the learning in this unit contribute to your development as a professional in your chosen field?
- (6) Imagine yourself in 15 years' time. What will you be doing? What do you dream you have achieved as a professional over this time?

Two additional questions<sup>2</sup> were asked to determine whether students experienced threshold concepts. Meyer and Land [40] propose that many disciplines have concepts that are critical to students' studies and future work. In many disciplines the identification of these threshold concepts is an on-going concern. Often troublesome and challenging [41], Quinlan *et al.* [42] ascertain that "all threshold concepts are epistemologically transformative and ontologically transformative ... once a student has grasped the concepts they will 'see' the world differently—

their way of knowing (epistemology) and related ways of being in the world (ontologically) will change" (p. 586).

The two questions were

- (1) Have you learned anything transformative in this session? If so, what?
- (2) Do you feel a need to think further about anything raised in this session? If so, what and why?

### C. Procedures

Prior to the commencement of the study, approval was obtained from the Curtin University Human Research Ethics Committee. Activities were delivered in the form of an interactive, two-hour workshop that featured self-reflection, group work, and group discussion.<sup>3</sup>

The workshops were held during regular classes so that all students could participate; however, engagement in the study was entirely voluntary. As such, students could decide whether or not to submit their responses for analysis. Participating students signed a consent form and were assured that their responses would remain anonymous. At the end of the workshop, consenting students placed their worksheets in an envelope and in a "post box." Students who did not wish us to use their material placed an empty envelope in the post box.

The data were analyzed using content analysis. Students' responses to three questions on the self-reflection worksheets: characteristics of a professional in their field of study; differences between self and these characteristics; and how learning in the unit will contribute to development as a professional, were first coded independently by two of the researchers. *A priori* codes (developed from a related project, see Ref. [43]) covered technical knowledge, technical skills, social and professional communication, lateral thinking, organization, teamwork, personality, intelligence, engineering as high status, and engineering as challenging.

Once initial coding was complete, we met to resolve discrepancies in coding. Differences in coding were attributable to three main factors. First, disciplinary differences resulted in differing ways of interpreting data and codes. Three of us have disciplinary backgrounds in education, science and psychology, respectively, and bring these differing perspectives to the task. In particular, there were differences in understanding of personality traits, intelligence, and where concepts such as leadership fit within the coding structure. Second, many student responses were brief and the limited information provided was in some cases ambiguous. This resulted in coding being influenced by coders' assumptions of what was meant. Third, the *a priori* codes were found to be insufficient to cover all responses and some codes were inadequately defined.

<sup>2</sup>We acknowledge the role of Dr Sally Male (University of Western Australia) in developing the two-minute paper.

<sup>3</sup>The complete workshop plan is available at <http://life.curtin.edu.au/careers/graduate-employability.htm> and also from us.

Following discussion, some codes were merged (e.g., professional and social communication were merged into the code communication skills; creativity, lateral thinking, problem solving, and traits were merged into the code personality characteristics) and some new codes created (e.g., values). After discussion, agreement on coding was reached for all responses. Student responses to the two-minute paper were analyzed using content analysis. No *a priori* codes were used.

#### IV. RESULTS

Our first research question asked how students characterize professionals in their chosen field. The perceived characteristics of professionals in students' chosen professions are presented, by occupational grouping, in Table II. The results indicate similarities and differences across occupational groups. For all three occupational groups, more than half of respondents provided characteristics that included personality traits (broadly defined to include creativity, lateral thinking, problem solving and other traits). Two other characteristics—social and professional communication, and intelligence—were included by more than 10% of students across each of the three occupational groupings.

Technical knowledge was included by more than a quarter of students planning careers as building and engineering professionals, but included only half as frequently by those planning careers as natural and physical science professionals and not included at all by the small group of students planning other careers. Example quotes

for each characteristic by occupational grouping are provided in Table III.

Our second research question asked what differences students perceive between themselves and the characteristics of professionals in their chosen field. The results are presented in Table II. Across occupational grouping, the most commonly reported area of difference was personality. More than 15% of students planning careers as engineering professionals or natural and physical science professionals noted differences in technical knowledge. Social and professional communication skills were noted as differences for more than 10% of students planning careers in the natural and physical sciences or other areas. Sample quotes for each characteristic by occupational grouping are provided in Table IV.

Some students reported no differences between the perceived characteristics of professionals in their chosen profession and themselves, perhaps representing a lack of insight or overconfidence, with one student commenting “None. So does this mean I can retire now?” Differences in characteristics between students and professionals may represent a matter of degree rather than absolutes. As one student commented: “I believe that I possess all of the above qualities in some form. However, I believe I will need to develop these attributes much further so that I may be able to reach my full potential in this profession.”

Our third research question asked how students thought the learning in the unit might contribute to their development as a professional. The results are presented in Table V. Across disciplines, many students recognized the unit would develop their technical knowledge, and (with the

TABLE II. Student perspectives of the characteristics of professionals in their chosen career, how the self differs from this, and how learning in the unit will contribute to development as professional, by occupational grouping (%). Note that N & PSP = Natural and physical science professionals, B & EM = Building and engineering professionals.

	Perceived characteristics of professional (%)			How self differs			How learning in unit contributes (%)		
	N&PSP (n = 32)	B&EM (n = 55)	Other (n = 6)	N&PSP (n = 32)	B&EM (n = 55)	Other (n = 6)	N&PSP (n = 32)	B&EM (n = 55)	Other (n = 6)
Technical knowledge	13	27	0	16	22	0	56	73	33
Technical skills	6	16	33	6	4	0	5	13	0
Social or professional communication	13	18	17	13	4	17	6	4	17
Organization	6	16	17	0	9	0	0	4	0
Teamwork	6	7	0	0	5	0	0	4	0
Personality characteristics	72	58	83	38	25	33	9	9	0
Intelligence	22	18	17	6	11	0	0	0	0
Deep knowledge	0	7	0	3	2	0	6	0	0
Values	25	5	17	9	4	0	0	2	0
High status	9	13	17	9	0	0	3	0	0
Challenging work	9	7	33	0	2	17	0	0	0
No difference				3	9	0			
Unit as first step							47	36	50
No response	6	4	0	31	22	33	3	4	17

TABLE III. Example responses for each category of perceived characteristics of professional by occupational grouping. Note that N & PSP = Natural and physical science professionals, B & EM = Building and engineering professionals.

	N&PSP	B&EM	Other
Technical knowledge	<i>Broad chemistry knowledge</i>	<i>Knowledge of all areas to design as efficiently as possible</i>	...
Technical skills	<i>Strong Chemistry skills</i>	<i>Good engineering skills</i>	<i>Analyzing data</i>
Social and professional communication	<i>Open to new ideas—good listener</i>	<i>Interpersonal skills; Communication skills</i>	<i>Good communication skills</i>
Organization	<i>Managing the time efficiently</i>	<i>Time efficient</i>	<i>Organizational skills</i>
Teamwork	<i>Good team and communication skills</i>	<i>Team player</i>	...
Personality characteristics	<i>Critical thinker; Open minded or creative; Independent</i>	<i>Logical reasoning; Problem solver; Practical and curious</i>	<i>Problem solving; Creative; Logical</i>
Intelligence	<i>Calculative; Smart</i>	<i>Good brain</i>	<i>Cognitive thinking</i>
Deep knowledge		<i>Deep knowledge in the required area</i>	...
Values	<i>Provide energy in a nondestructive manner; environmentally responsible; Socially responsible</i>	<i>Pure heart</i>	<i>Positive</i>
High status	<i>Smart; rich; have trophy wife</i>	<i>Contribute for my world; Being remembered; Want to be a rich man</i>	<i>Rewarding</i>
Challenging work	<i>Challenging</i>	<i>Work under pressure and strict timeframe; Awareness of your responsibility</i>	<i>Challenging</i>

exception of students planning other careers) technical skills. A theme emerging from this analysis, and present across occupational groupings, was that the material taught in the unit provided the first step towards consideration of further study and potential career pathways. Example quotes by occupational grouping are provided in Table V.

Our final research questions asked whether students perceived the possible selves workshop as transformational. Responses from the two-minute paper were analyzed using content analysis. The first question on the two-minute paper asked whether students had learned anything transformative in the workshop. Seventeen (18%) of the 93 students did not respond to this question. A further 25 (27%) stated they had not learned anything transformative. Where this was elaborated upon, students commented that they had already given consideration to their future careers (“*already thought about this stuff*”; “*I had a pretty good idea about all this already*”), and had a clear career direction (“*I still want to be a chemical and metallurgist*”) which the workshop activities may have reinforced (“*I am more confident about my career choices*”).

Other responses were consistent with the aims of the workshop. Nine students (10%) commented on the opportunity to self-evaluate strengths and weaknesses: “*This was more like a self-reflection. For example, think about what I’m going to do and what I like doing. This session was amazing overall*”.

Students commented on the tendency to focus on their weaknesses (“*I do have more strengths but I struggle to*

*recognise them perhaps because I take [them] for granted. I tend to focus on things I’m bad at the most*”) and the difficulty in identifying their strengths: “*It’s pretty tough to think of good things about yourself*”, with one commenting, “*I’m good at more things than I thought*”.

Comments from 15 (16%) of students indicated that the workshop had provided them with a vision of the future (“*Clearer vision of what I want from my course and how I am going to get there*” and “*Redefined what I’m working towards. A better future*”) and the need to plan for how to achieve this (“*I have learnt that, the mind chooses what the mind wants. That leads to determination. It is the (our) determination to achieve a specific goal which leads us to certain decisions like our units, careers etc.*” and “*I must always use my future goals to drive me through this degree*”).

Related to this, five students (5%) reported they had learned more about their planned profession, including the range of occupations “*I’ve learned that there are different views and different areas that engineers work in,*” providing more information on which to base career decisions: “*I have learnt that chemistry is diverse even within physics and thus changed how I think about future employment*” and “*I established more realistic roles of engineers in my field.*”

The workshop provided the opportunity for students to interact with each other: “*Got to know more people*” and “*It’s been encouraging to speak about engineering with like-minded people.*” Twenty-two students commented on

TABLE IV. Example responses for how the self differs from the perceived characteristics of professional by occupational grouping

	N&PSP	B&EM	Other
Technical knowledge	Right now, I lack the technical knowledge. After unit, this will hopefully change.	Could improve my math or science despite having a strong foundation	...
Technical skills	Skills and knowledge; a current lack of 'knowing' the optimal way to conduct things	I don't know much about working with metal yet	...
Social and professional communication	Would like to improve on the social side of things, I could try to be more talkative.	I am not as communicative as I should be	I need to work on my communication skills, to talk more professionally
Organization	...	I am not very well organized	...
Teamwork	...	I'm not much of a leader. I'm very quiet and follow others	...
Personality characteristics	Determination. Don't have enough persistence on what I believe in.	I am not good at solving problems. Most of the time, I prefer discussing my problems to my friends first before I actually do	I am not yet gathered all skills of being a leader effectively
Intelligence	I'm not wise, not particularly intelligent and I doubt I'm interesting	I am not smart yet. Hopefully that will change with hard work and persistence throughout university life	...
Deep knowledge	Skills and knowledge ... the optimal way to conduct things (i.e., socially and environmentally responsible ways to shop, companies that adhere to these values)	I am not yet highly knowledgeable within the field of electrical power engineering	...
Values	The major difference between me and an env. Engineer is mainly the environmentally conscious part. Though I try to be, there are still key aspects that I find very hard to change	The differences are all of my characteristics would serve and protect people	...
High status	I'm not rich. I'm not married	...	...
Challenging work	...	... trying but I am not sure that I am good or not	I consider (working hard) different because it requires the most effort

this aspect of the workshop, referring to the opportunity to meet other students from the same discipline: *"I have learned that there are lots of Chemical Engineers in this unit."* Students noted both the commonalities among students (*"Re-realised the there are others feeling the same; People out there who can give me help"*) and the differences (*"everyone has different idea of what they would become in the future"*).

Some students commented on the opportunity the workshop provided to learn about group work: *"Understand the purpose of group work"* and *"learnt how to work in group and sharing our ideas."* The sharing of common concerns was seen as beneficial: *"It's reassuring to know I am not the only one with uncertainties, insecurities, and feeling perhaps a little apprehensive about decisions made thus far. It's been a great session that has made me feel a sense of invigoration to studying this semester."*

Four students commented directly on the unit, indicating they had learned about the difficulty of the unit and its high failure rate, but also that they had developed strategies or plans for learning in the unit: *"I've also learned the things that will help me pass the unit."*

The second question asked whether students felt a need to think further about anything raised in the workshop. Almost half (45) of the students did not respond to this question and a further quarter (27%) stated they felt no need to think further about things raised in the workshop.

Of those who did respond, areas reported as requiring further thought included future aspirations (9 responses, e.g., *"Think about what I am going to do in future and what do I really like and want to do"* and *"My whole course; the purpose it serves and how can apply what I learn in this workshop in a real world situation"*) and self-evaluations



TABLE V. Student perceptions of how learning in the unit will contribute to their development as a professional in their chosen field, by occupational grouping.

	N&PSP	B&EM	Other
Technical knowledge	<i>Provides strong fundamentals in Advance Physics which is necessary to the renewable energy program</i>	<i>This will add to my foundation of knowledge in electricity and magnetism</i>	<i>And I'll be teaching Yrs 8–10 so need to know a bit about physics</i>
Technical skills	<i>Pre-requisite skill needed, also will help with electrical physical properties</i>	<i>Physics is a key component of all engineering and so this unit will have a huge impact on the development of such required skills</i>	...
Social or professional communication	<i>Communication</i>	<i>I will have various new social skills to relate with co-workers</i>	<i>We learn COMMUNICATION!!</i>
Organization	...	<i>It will be easier to meet strict deadlines and expectations</i>	...
Teamwork	...	<i>Working in a team</i>	
Personality	...	<i>Learning to problem solve is good</i>	
Deep knowledge	<i>It will give me a fundamental grasp on the way elements in the natural world interact with each other</i>	...	...
Values	...	<i>I would like to teach in a rural area where I can help teenagers who are less advantaged learn Yr 11 &amp; 12 science</i>	...
High status	<i>Help build my skills in chemistry in order to further my future job potential</i>	...	...
Unit as first step	<i>The learning in this unit will give a solid foundation to the challenges I might face in my profession</i>	<i>It will give me a firm understanding of physics which will allow me to make intelligent decisions when I'm at work in my chosen profession</i>	<i>Physics is an important subject in general and starting out as a Lab tech in oil and gas I think it has plenty of relevance</i>

(6 respondents, e.g., “*What I'm good at because it seems important to play to my strengths*”). Two of these responses indicated possible major changes: “*is this really what I want to spend my time doing*” and “*I don't know what I'm going to do with my life*.” Two further responses indicated students may be experiencing difficulties with the unit content: “*All of the things I need to think about are technical*” and “*The amount of math and computer work made me rethink but I will soldier through it*.”

## V. DISCUSSION OF FINDINGS

We set out to find ways in which to engage first-year university students from a range of disciplines in a foundation physics unit. The possible selves framework enabled us to examine the extent to which students were able to define or perceive themselves in terms of roles, attitudes, beliefs, and aspirations. The results from our workshop provide some support for our aim of developing learners who are able to view their learning in relation to their future career aspirations.

Most students were able to identify at least some characteristics of professionals in their chosen field. An interesting finding was the strong focus on personality

characteristics of professionals, broadly defined to be inclusive of creativity, lateral thinking, and problem solving characteristics. Technical knowledge and skills were referred to with far less frequency, as were intelligence, social skills, and professional communication skills. Values were mentioned by a quarter of students planning careers as natural and physical science professionals, reflective of the number of students in this category planning careers in environmental or renewable energy engineering.

Students had greater difficulty in identifying the differences between themselves and the characteristics of professionals in their chosen field, with up to one-third of students in each occupational grouping not responding to this question. This suggests that the concept of comparing the current self to a future possible professional self was somewhat novel to these students and may require further attention over the course of the degree. It may also suggest that these students did not know the characteristics of professionals in their chosen profession, or that they were uncertain about their choice of profession at that point. Of those students who did provide answers, the key areas of difference identified were personality characteristics and technical knowledge.



Students' responses to how learning in the unit might contribute to development as a professional were strongly centered on increasing technical knowledge. This was supplemented with statements that the unit provided the first step to becoming a professional. In the Australian context, most majors who are required to take foundation physics will use it in their degree programs and careers to some extent, but its relevance may not be clear to students. In highlighting the need to make this relevance explicit we emphasize Redish *et al.*'s observation that creating a social contract between students and lecturers might "explicate the elements of an appropriate set of expectations ... [and] move students from a binary view of learning to a more constructivist set of attitudes in the first term of university physics" [[44], p. 222].

In terms of personality characteristics, students perceived professionals as being critical, open-minded, and independent thinkers able to solve complex problems. Students expressed particular doubts about their own ability to solve complex problems and they were concerned about the need to be independent, or to lead decision making. Of interest, the unit was not seen by most students as contributing to personality characteristics, which were the most widely identified area of difference between the current and future professional self.

Similarly, although the unit in which the study was housed was run as a series of hands-on workshops within which students often worked in groups in guided inquiry activities, students did not relate these activities to their development of the personality characteristics outlined above.

Encouragingly, the majority of students identified transformational elements of the workshop. Self-reflection resulted in some students identifying strengths, although many students struggled with this challenge. As a result of participating in the workshop some, but not all, students were able to identify personal strengths, to envisage a future professional self, and to begin to think about their current studies in relation to this.

The ability of students to visualize themselves into the future depends in part on their ability to employ sociocognitive strategies: strategies that consider both environment or context and intrapersonal factors. This future-oriented thinking supports the use of possible selves to explore broad and inclusive career previews, recognizing that identity is a process of becoming rather than an end point. Exploration of self and future also aligns with the enhancement of first-year experience in that negotiating the higher education environment is problematic for many students, particularly those who are studying internationally, are not from high socioeconomic status backgrounds, and/or are first in their family to attend university.

Given that students need to "develop their own authentic voices at the outset of their professional education" [[7], p. 17], first-year foundation units emerge as a logical site in which to begin the process of examining possible future

selves. Our initial results add weight to the findings of other studies, which have concluded that the ability of students to evaluate themselves in relation to their possible futures is a critical and neglected aspect of higher education [5,6]. Indeed, Erikson [45] considered this ability to be an indicator of academic performance and Berzonsky's later research [46] concluded that sociocognitive strategies are central to students' abilities to negotiate their first year of post-secondary study.

Of concern, Scanlon *et al.* [30] suggests that many first-year students struggle with the lack of contact with lecturers, inadequate feedback on their progress, and the vastly different modes of communication such as unit outlines which may be the only mention of an assignment and its due date. Scanlon *et al.* determined that these factors are "constraints on student identity formation in that the acquisition of cultural capital was not always facilitated by lecturers" (p. 234). The workshop described here encompassed immediate feedback from lecturers and peers alongside opportunities for students to reflect alone and with others about their learning and its relevance to their future lives and careers. Moreover, students came to know one another in class—to develop learning communities within and outside their discipline. We contend that these communities are important aspects of the capitals on which students draw within their first-year experience, highlighted by Johnson *et al.*'s [29] assertion that student engagement in active learning communities is an important factor in engagement, persistence, and achievement.

Bourdieu and Passeron's notion of cultural capital [31] supports the idea of identity as a process of becoming and the ability of students to negotiate different contexts as they transition into their new environment; however, we highlight that this responsibility does not lie solely with academic staff. The findings of this study suggest that once they have begun to engage in future-oriented thinking, students may become active participants. This was observed anecdotally in the students' engagement in successive classes and also in their regular contact with their foundation unit peers outside of the class, even when these peers were not in the same discipline or degree program.

Longitudinal research would determine the extent to which this is the case and the degree to which lecturers need to be the facilitators of successive interactions. It might also provide evidence of whether the "dose" of a single workshop within an already interactive unit is sufficient to maintain long-term gains or measurable change in learning attitudes on measures such as the Colorado Learning Attitudes about Science Survey (CLASS) [47].

One of the most important indicators of success found in Scanlon *et al.*'s study [30] was that of critical interaction. In responding to the question about transformational learning and mindful that students in our study valued the workshop's opportunities to interact, work in groups, and share common concerns, we believe that future research may

benefit from the inclusion of teamwork and/or classroom sense of community measures to capture this aspect.

Finally, we suggest that future research might seek to ascertain to what extent a growth mindset rather than a fixed mindset [48] might influence learner behavior within foundational courses and, further, whether the development of a growth mindset might enhance learners' engagement with and achievement within these units of study. In particular, research might seek to extend the work of Megowan-Romanowicz *et al.* [49] with specific reference to growth mindset and the development of healthy identities in the discipline of physics.

## VI. RECOMMENDATIONS FOR INSTRUCTION

We offer some recommendations for physics educators who would like to further engage students from across disciplines in physics education.

These recommendations center on assisting students to view their learning in relation to their future career aspirations. We recommend more explicit reference in the curricula to the development of attributes such as creativity, lateral thinking, teamwork, and problem solving in order to help students to see the relevance of their studies to their future careers, and to see this in light of making the transition from expert student to novice professional [50]. To enable this we advocate for the incorporation of interconnecting factors identified by Bhattacharyya and Bodner [20], with the additional focus of self and identity as follows:

- (1) Ensure that students perceive the material they are asked to learn as authentic and of relevance to their future lives and careers.
- (2) Set authentic learning activities so that students engage in concrete instruments for knowledge construction and relate these back to their development of personal and professional skills and knowledge.
- (3) Scaffold student learning by providing feedback from knowledgeable others and from peers.

We also recommend that such changes be evaluated in order to establish their impact on student attitudes and student learning. Existing reliable, validated measures of beliefs about physics and learning physics (e.g., CLASS [47]) are ideally suited for this purpose.

## VII. SUMMARY

In summary, our research has demonstrated the applicability of the possible selves framework to designing activities that engage first-year university students in foundational science units. Our results suggest that students experience immediate benefits from these activities through self-reflection on the current self, future possible professional selves, and the role of current studies in narrowing the gap between the two. This is despite students' disparate discipline majors. Further research is required to determine the longer-term effect of these activities on pass rates and student retention, and a continued focus on these aspects within the context of higher education would be welcome.

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