How future educators view themselves and their profession: A study of pre-service science educators

Rachel Sheffield, Susan Blackley and Dawn Bennett
Curtin University, Australia

Attrition of up to thirty per cent in the initial years of a teaching career has led to a high level of disillusionment in teaching as a desirable and rewarding profession. Although many nations have responded with substantial investments in pre-service teacher education, these efforts have failed to dissuade newly qualified teachers from leaving the profession. An important factor in professional membership is a sense of identity to both a particular group of people and a set of established practices. This article examines the initial identity of pre-service science teachers who belong to the science, technology, engineering and mathematics (STEM) cohort of teachers in the primary and secondary initial education programs at an Australian university. We consider the alignment of participants' initial professional identity, including career commitment, with their concerns about entering the teaching profession. Recommendations are made for actions that might reduce the early career exodus.

Background and context

In this paper we capture the early professional identity of pre-service science teachers in three initial teacher education (ITE) programs, prior to them undertaking their first professional placement in schools. The students were enrolled in the primary and secondary initial teacher education programs at an Australian university; the secondary students were specialising in science, technology, engineering and mathematics (STEM) education. At the time of the study, the students were all taking a second-year unit entitled *Inquiring in the Science Classroom*.

Our study was prompted by the attrition of between 30 and 50 per cent of teachers within the first five years of their teaching careers (Gallant & Riley, 2014; Skilbeck & Connell, 2004), which is a terrible loss for schools and students and also leads to disillusionment in teaching as a desirable and rewarding profession (see Haynes, 2014; Jacques et al., 2017). Similar rates of attrition have been reported in multiple Australian States and Territories, with even higher rates in many regional and rural areas (Singhai, 2017; Skilbeck & Connell, 2004; Weldon, 2018; Weldon, Shah & Rowley, 2015) and similar rates reported in other countries (see, for example, Worth, Bamford & Durbin, 2015).

In the higher education (tertiary) environment, Trede and McEwen (2012) reminded us that an important factor for students is the development of a sense of identity aligned with both a particular group of people—people in their intended profession—and the established practices of those professionals. In recent times, both the formation of teacher identity and initial teacher education programs have come under scrutiny in this regard (Loughran, 2014; Masters, 2017; Thomson, Wernert, O'Grady & Rodrigues, 2017). In an earlier study with generalist primary education pre-service teachers (Blackley, Bennett & Sheffield, 2018), we provided opportunities for students to engage reflectively with their university and professional contexts and found that these opportunities contributed to positive professional identity formation. In the study reported in this paper, we sought to understand how pre-service science teachers (PSTs) in both primary and secondary initial teacher education courses envisioned themselves as science educators, probing their concerns about becoming science educators, how they characterised effective science teachers, and where they saw themselves in ten years' time.

Education authorities strive to provide students with opportunities to develop positive dispositions to learning, to acquire both discipline-specific knowledge and global competencies, and to explore other ways of knowing including those relating to traditional histories and cultures (see, for example, Australian Curriculum Assessment and Reporting Authority, 2019). In Australia, the *Melbourne Declaration on Educational Goals for Young Australians* (2008, p. 7) proposed that equitable, quality education should enable "all young Australians to become successful learners, confident and creative individuals, active and informed citizens". These goals and aims have changed little in over a decade and they have considerable relevance to a higher education sector in which the student population is increasingly diverse and the competition among graduates is unprecedented (Burke, Scurry, Blenkinsopp & Graley, 2017).

In Australia, the analysis and reforming of initial teacher education is on-going and compelling, with the formation in 2014 of a National Teacher Education Ministerial Advisory Group (TEMAG) and the release, in 2015, of an Australian Government report titled *Action now: Classroom ready teachers* (Australian Government, 2015). As Rowe and Skourdoumbis (2019) pointed out, however, "classroom readiness" is yet to be defined, and consensus on a definition may be some time away. Classroom readiness might relate to demonstrable positive student learning outcomes, content knowledge, classroom management and pedagogical skills, professional satisfaction and/or reduced graduate teacher attrition. We propose that pre-service teachers' readiness, self-efficacy and integration into the teaching profession might also be enhanced by the explicit development of their teacher or professional identity.

Identity

There is a plethora of research on the importance of professional identity for new teachers. Avalos and De Los Rios (2013), Ballantyne and Zhukov (2016), and Bennett (2013) all asserted that identity is crucial to the academic self-efficacy and self-concept of pre-service teachers. Identity is understood as a reflective socio-cognitive process developed over time and in relationship with others. Pre-service teachers' expectations of their role as a *teacher* are based on their experiences through cultural norms, the media, and their own experiences in the classroom as students (Blackley, Bennett & Sheffield, 2018; Gallant & Riley, 2014). As such, pre-service teachers need considerable support to develop their sense of teacher identity. Such support might be merited, given that "developing a strong sense of a professional identity as a teacher may be crucial to the well-being of new members of the profession" (Thomas & Beauchamp, 2011, p.762) and it might in turn help to reduce burn-out and early career attrition.

According to Beltman, Glass, Dinham, Chalk and Nguyen (2015), the key precedent of pre-service and neophyte teacher identity is the individual's life history, and in particular the individual's personal experiences of school and schoolteachers. The experience of university classrooms and the different landscape of the school "as workplace" may create a strong sense of cognitive dissonance between what pre-service teachers expect and what they experience. Trede and McEwen (2012, p. 9) contended that "challenging students to reflect on who they are and who they want to become provides them with a lens through which to make sense of and enrich their learning experiences". A complicating feature of pre-service teacher education is that students might alternate between multiple identities, as teaching student or learner, as novice teacher, and perhaps as a professional in their substantive discipline. Fluidity between these multiple identities is also likely to encompass the desired, expected and feared future selves described by Markus and Nurius (1986) as *possible selves*.

STEM education

Over the past two decades, STEM and derivatives such as STEMM (with the addition of medicine), STEAM (with the addition of the arts) and STEAMM (inclusive of the arts and medicine) have become a focus of continuous funding and policy attention internationally. This attention was led and is still being driven by the United States in a strong "nation-centric" (Steele, Brew & Beatty, 2012) reaction to the global financial crisis and consistently poor rankings in international assessments of student achievement, including the *Program for International Student Assessment* (PISA) and the *Trends in Mathematics and Science Study* (TIMSS).

In Australia, the current focus on STEM has been fuelled by a 2016 report from the Office of the Chief Scientist, which began with the statement, "Australia's future will rely on science, technology, engineering and mathematics (STEM) disciplines at the core of innovation" (p. 2). The report goes on to describe STEM disciplines as "the lifeblood of emerging knowledge-based industries, such as biotechnology, information and communications technology (ICT) and advanced manufacturing, and provide a competitive advantage to established industries such as agriculture, resources and healthcare" (Office of the Chief Scientist, 2016, p. 2).

The Office of the Chief Scientist has also articulated the importance of STEM education as follows:

> Strong performance in STEM is also critical to our education sector—now Australia's fourth largest export industry. An education in STEM fosters a range of generic and quantitative skills and ways of thinking that enable individuals to see and grasp opportunities. These capabilities—including deep knowledge of a subject, creativity, problem solving, critical thinking and communication skills—are relevant to an increasingly wide range of occupations. They will be part of the foundation of adaptive and nimble workplaces of the future. (Office of the Chief Scientist, 2015, p. 3)

In comparison with other developed nations, however, Australia is troubled by poor performance in science and mathematics. This performance was summarised by Sheffield, Koul, Blackley, Fitriani, Rahmawati and Resek (2018, p. 70), who concluded that

> … as indicated by the NAPLAN (National Assessment Program Literacy and Numeracy), PISA (Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) trend data, [Australian] student performance in science and mathematics in the compulsory years of schooling has flat-lined, showing no significant improvement over the last eight years.

It would appear, then, that targeted funding and the creation of classroom-ready STEM resources have failed to improve Australia's international standing amongst the member countries of the OECD; neither have they led to improvements in national student achievement in mathematics.

One possible contributor to Australia's poor performance in science and mathematics assessments relates to the coverage of STEM's four components at the school level. The United States' school-based science curriculum has included engineering for many years (National Research Council, 2011). In Australia, however, engineering is not taught during the compulsory years of schooling (from kindergarten to Year 10) and it is rarely taught in the senior years (Years 11 and 12). As a consequence, teachers in Australian schools reduce the attention to or ignore the "E" component of STEM (Australian Curriculum Assessment and Reporting Authority, 2013).

A further constraint on Australia's STEM education performance is the "T" for technology, which can be aligned with generic information communication technologies (ICT) capabilities as defined within the Australian Curriculum or, more specifically, with the distinct discipline area known as the *Australian Curriculum: Technologies*. There is also jostling for primacy (and funding) between STEM, STEAM, STEMM and STEAMM. The National Academies of Sciences, Engineering and Medicine (2018) have echoed Burke and Baker McNeill's (2011) earlier concerns and questioned whether there is sufficient room for the arts, humanities and medicine within the STEM umbrella, or whether STEM should remain more bounded, adhering to the original suite of four disciplines.

A third challenge for STEM performance, particularly in secondary school classrooms, is that STEM subjects tend to be taught and assessed by specialist subject area teachers rather than across the STEM disciplines (Blackley & Sheffield, 2015); STEM has essentially been taught as S.T.E.M., with each discipline taught separately. As Blackley and Howell (2015) explained, STEM education and *integrated* STEM education add a new dimension to the STEM debate, and has ensuing implications for learning and teaching. A strong argument for integration is that it would develop "the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and to innovate to solve them" (Balka, 2011, p. 7). Bellanca and Brandt (2010), Dede (2009) and Australia's Office of the Chief Scientist (2016) took this a step further, arguing that an integrated approach to STEM creates opportunities for students to develop 21st-century competencies such as creativity, critical thinking, communication and collaboration.

The study we report on in this article contributes to the research on STEM identity by examining pre-service teachers' perceptions of themselves as "teachers of science". In seeking to understand aspects of emerging professional identity, we consider the alignment of participants' initial professional identity, including career commitment, with their concerns about entering the teaching profession.

Research design

This was a qualitative study designed to elicit deep responses through a combination of textual and visual data. The study asked second-year pre-service science educators to conceptualise themselves as a science teacher and to consider three points: the characteristics of effective science teachers; their concerns prior to their first professional placement; and their thoughts about their future careers. We selected the second-year cohort for two reasons. First, they were yet to experience their first school placement and we wanted to give them opportunities to explore their teacher identity prior to that professional experience. Second, the second-year curriculum contained a unit entitled *Inquiring in the Science Classroom*. This was taught to a combined cohort of primary, secondary and graduate diploma students and therefore presented an opportunity to engage students across all three programs. Primary students were able to create a more integrated approach to their teaching, however, the Secondary and Graduate Diploma students were totally focused within the science curriculum.

The study employed an arts-informed methodology which results in generative rather than propositional knowledge (Cole & Knowles, 2008). McNair and Stein (2001) and Gauntlett (2005) proposed that the personal relevance of drawings can help individuals to think more deeply about their understandings and relationships. The creation of visual artefacts such as drawings provides a mindful space in which students can engage in reflection, introspection and self-understanding (McLean, Henson & Hiles, 2003).

A number of researchers have indicated a link between pre-service teachers' (PSTs) free-hand drawings of their possible selves and the development of their professional identities as educators (see Beltman, Glass, Dinham, Chalk & Nguyen, 2015; Bennett, 2013, 2016; Brand & Dolloff, 2002; Freer & Bennett, 2012; Garnesh, 2011; McLean et al., 2003; Mitchell, Theron, Stuart, Smith & Campbell, 2011). Drawings might also help students to express group values, as students, as teachers, and as members of a discipline. This was an important consideration because the majority of extant research on science identity relates to scientists rather than *science educators*.

Initial attempts to articulate what a scientist looks like were marred by controversy due to the male stereotypes that resulted. This was seen in Chambers' (1983) seminal research into student and pre-service teachers' perceptions of scientists using the *Draw-a-Scientist-Test* (DAST), which resulted in multiple illustrations of men in white coats. The controversy led to modifications of the test by Finson, Beaver and Cramond (1995), and also by Thomas, Pederson and Finson (2001), who added a narrative component or caption. The resulting DAST or DASTTC *Draw-a-Science-Teacher-Test Checklist* has been employed successfully in a number of studies (e.g., Beltman et al., 2015; Garnesh, 2011; Mitchell et al., 2011), and scholars have since incorporated an explanatory caption in their arts-informed research to "expose underlying assumptions, promises and predispositions, including those that represent and regulate the processes of identity development" (Bennett, 2015, p. 102).

The research team applied the *Concerns-Based Adoption Model* (CBAM) (Hall & Hord, 1987) to categorise the concerns expressed by participating pre-service teachers. This model was from the work of Fuller (1969) who proposed that teachers and pre-service teachers were preoccupied with thoughts of themselves, tasks and impact and that there was a continuum to these stages through which teachers and pre-service teachers progressed over time. This was later expanded to include sub-stages within the stages as shown at Table 1.

Table 1: Stage of concerns

Concerns	Stages of concerns		
Impact	6	Refocusing	Refocusing an innovation: making major and/or minor changes to make it more efficient for the teacher.
	5	Collaboration	Collaborating and coordinating with other teachers regarding the use of the innovation.
	4	Consequence	Evaluating student outcomes and subsequent changes required for improvement.
Task	3	Management	Focusing on the processes, tasks and issues related to organising, managing and timetabling.
Self	2	Personal	Understanding the demands of implementing the innovation (cost, time and status implications).
	1	Informational	Gathering information about the innovation but having little opportunity to evaluate it in relation to the teacher's position.
	0	Unconcerned	No concerns as there is no involvement with the innovation.

Research questions

In this study, we study sought to answer three questions:

1. How do pre-service science teachers in primary and secondary initial teacher education programs envision themselves as science teachers?
2. What are the concerns of pre-service science teachers in relation to becoming science teachers?
3. How do pre-service science teachers characterise effective science teachers?

Participants

A total of 160 students were invited to participate in the study. The participants (N=158) were recruited from Bachelor of Education (Primary) students, Bachelor of Education (Secondary) students, and students in the one-year Graduate Diploma of Education (Table 2).

Table 2: 2017 Pre-service teacher (PST) cohort (N=158)

Qualification area	Degree program	Number
Primary school	B.Ed. Primary	59
Secondary school	Graduate Diploma (Grad Dip)	71
	B.Ed. Secondary	28

Primary school PSTs

The 59 Bachelor of Education (B.Ed.) Primary PSTs were enrolled in a second-year primary science unit entitled *Inquiring in the Science Classroom*. The three males and 57 females were aged between 19 and 25 years. The students had not yet been on their first professional placement, which was scheduled later in the same semester. The students in the B.Ed. Primary cohort were preparing to teach all subjects in a primary school setting, where students are aged between four and 11 years.

Secondary school PSTs

The secondary school PSTs were completing the lower secondary science unit and science was their major or minor subject area. The students were preparing to teach in secondary (high) school settings, where students are aged between 11 and 18 years. The secondary PST cohort included B.Ed. Secondary undergraduate students in their second or third year of a four-year undergraduate degree, and graduate students undertaking a 12-month Graduate Diploma (Grad Dip) in science and mathematics education.

The B.Ed. Secondary students (undergraduates) were majoring in either a science subject with a mathematics minor or a mathematics major with a science minor. In the B.Ed. Secondary cohort, 16 (57%) were male and 12 (43%) were female. They were all aged under 30, with the majority between 19 and 21 years, and the average age was 22 years.

The Graduate Diploma, students held undergraduate degrees with a major or minor in science. In this cohort, 39 students (56%) were male and 31 (44%) were female. Within the graduate cohort, 63% were aged under 30 years, 28% were between 31 and 40 years and 8% were 41 years or older.

Data instruments

The principal data instrument was derived from the visual narrative studies undertaken with university students by Bennett (2016) and used by the authors in our previous study (2018). We added to this questions on students' concerns about entering the teaching profession, drawing on the seminal work of Hall and Hord (1987). Students responded to four items in their reflective task, which was completed in class time:

- You are currently studying to be a science teacher. Please draw yourself as that teacher and describe what you have drawn.
- List 3 attributes that describe effective teachers of science.
- What are your 3 biggest concerns about being a teacher?
- Where do you see yourself in ten years' time and what will you be doing?

Procedures

The students in the B.Ed. Primary, B.Ed. Secondary and Grad Dip engaged in the pen-and-paper reflection, taking on average 20 minutes during class at the beginning of the semester, and they chose whether or not to include their response in the research dataset.

Data analyses

We note first that some graduate students (Grad Dip PSTs) had earlier pursued careers in science-related industries including engineering, geology and marine biology. We recognised that these PSTs might already have an established professional identity, possibly as a scientist or engineer; this might impact their teacher identity development and, possibly, their views on STEM education. As such, the B.Ed. Secondary and Grad Dip PSTs were coded separately.

First, each drawing and its caption was coded using the categories identified in our previous study (Blackley, Bennett & Sheffield, 2018); this obtained an inter-rater reliability of 95% agreement. The final coding categories were: Teacher only, teacher + artefacts, teacher + student, teacher + artefacts + students, metaphor, and no drawing. Next, the team coded the four text-based reflection items using a "naturalistic" coding process that started with reading each response without applying codes. We then employed a constant comparative analytical scheme that involved unitising and categorising the text. These units were subsequently brought together into provisional categories relating to the same content. Two coders were used to reduce error and bias in coding the transcripts (Mays & Pope, 2000).

To highlight differences in the reports of each student cohort, the results that follow are reported according to both student cohort and theme.

Results and discussion

Pre-service teachers' perceptions of themselves as teachers

The drawings were sorted as shown at Table 3 using the categories previously described: teacher only, teacher with artefact/s, teacher with student/s, teacher with artefact/s and students/, metaphor. Twenty per cent of the primary PSTs drew just themselves as the teacher. Some drawings were simple and contained a single element (e.g., Figure 1) whilst others were more complex. Seen at Table 3, artefacts were included between 20% to 25% of the time. Within the B.Ed. Secondary and Grad Dip cohorts, the majority of artefacts were chalkboards or white boards

Table 3: Coding categories for student drawings of themselves as a 'teacher of science'

Category	B.Ed. Primary %	Grad Dip %	B.Ed. Secondary %
Teacher	20	10	7
Teacher with artefact/s	20	24	25
Teacher with student/s	18	7	11
Teacher with student/s and artefact/s	39 (*8)	52 (*27)	57 (*28)
Metaphor	0	6	0
No drawing or caption	3	1	0

* Traditional desks and chairs

Primary PSTs were more likely (18%) than other cohorts to portray themselves in a traditional classroom setting with their students. Fifty-seven per cent of the B.Ed. secondary cohort drew the teacher with students and artefacts; almost half these students depicted traditional, more teacher-centred classroom environments where students were sitting in rows at desks and the teacher was at the front of the classroom. This was almost identical for the PSTs in the Grad Dip cohort who portrayed themselves in traditional classrooms in rows and themselves as the teachers at the front of the room in 28% of the responses. These appeared to be teacher centred with the teacher sharing their knowledge in a didactic mode and students in a more passive, listening role.

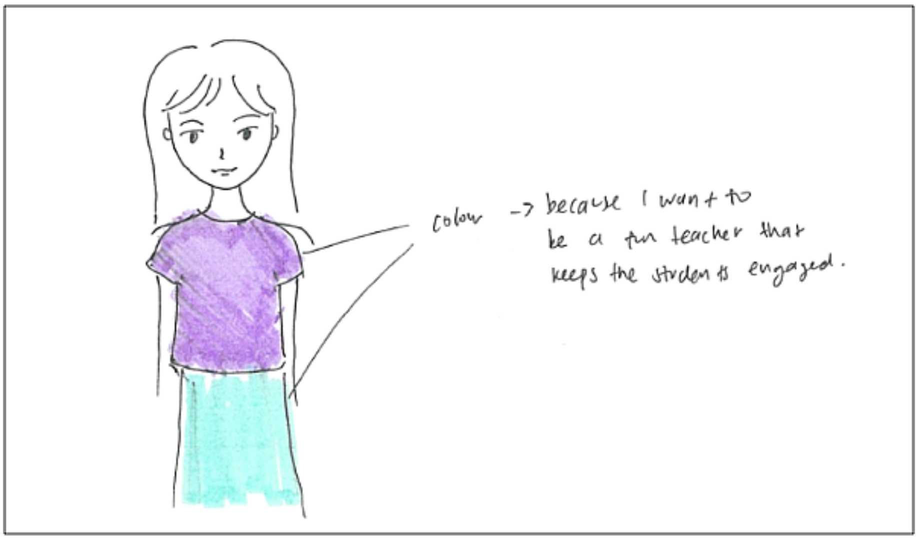

Figure 1: Example of a drawing with a single element: Self as teacher (female Primary PST)

The kinds of artefacts and the relative power positioning of students and teachers were of particular interest. Figure 2 is an example of what could be referred to as an archetypical teacher in a traditional education setting – note the authority of the pointer in hand. In contrast, Figure 3 shows a teacher and students observing sources of energy in an outdoor setting. The presence of clipboards and shovel suggests a more active learning setting where students are more actively involved in the learning.

Figure 2: The teacher in a traditional, teacher-centred classroom setting (male Primary PST). Caption: "Wearing a button-up [shirt] to look professional"

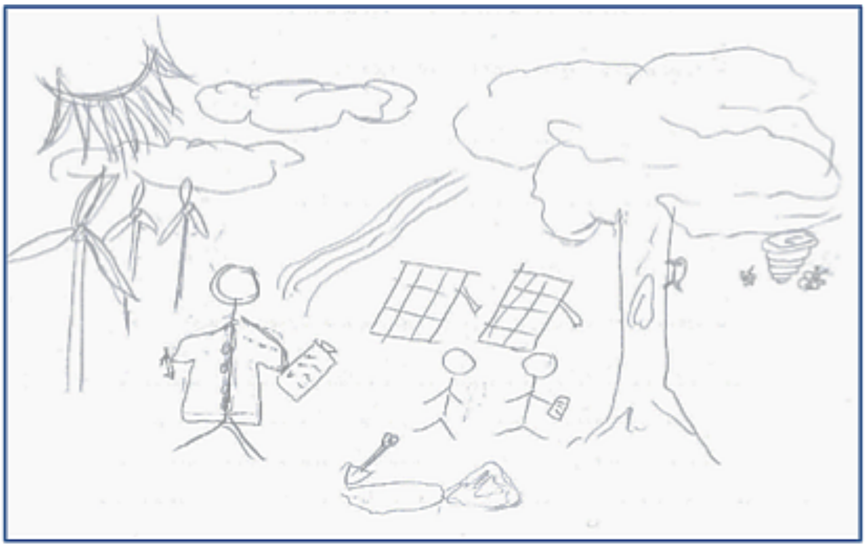

Figure 3: The teacher engaging with students in an outdoor setting (male Secondary PST). Caption: "Giving students a passion for science by engaging them in real applications of science"

Figure 4 illustrates an example of a pre-service teacher who envisages herself in a traditional classroom setting, in particular, a science classroom, as indicated by the teacher's raised demonstration bench. Despite the traditional setting, the student notes that she will stand "in front of the desk when possible". She also includes an interactive whiteboard, but this is separated from the learning space by the desk.

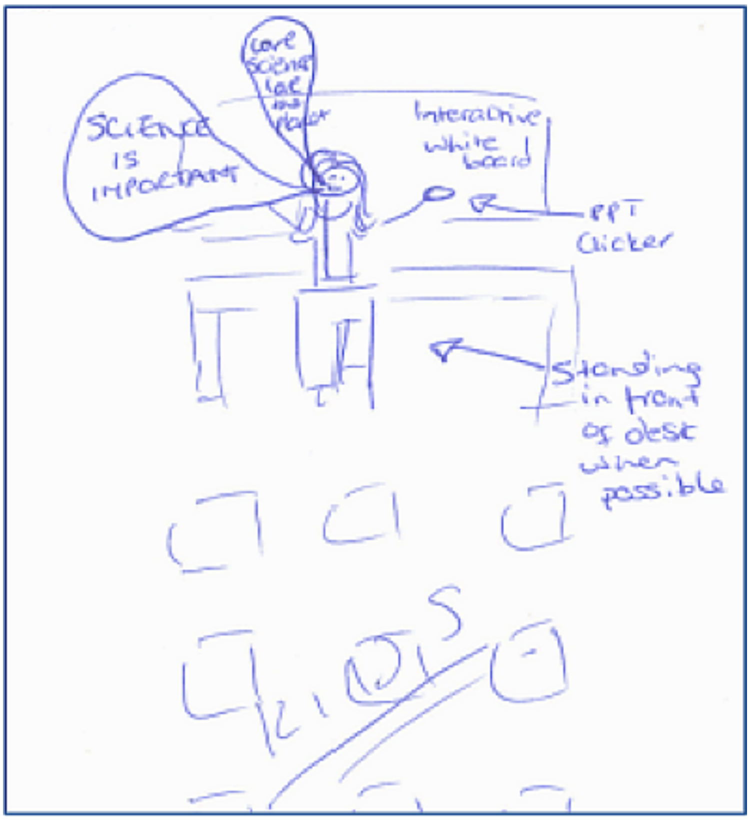

Figure 4: Representation of a science classroom with desks and chairs
(female Secondary PST).

The student who created the drawing shown at Figure 5 uses the metaphor of "cogs" to illustrate himself as a teacher. All seven metaphor drawings came from the Grad Dip cohort.

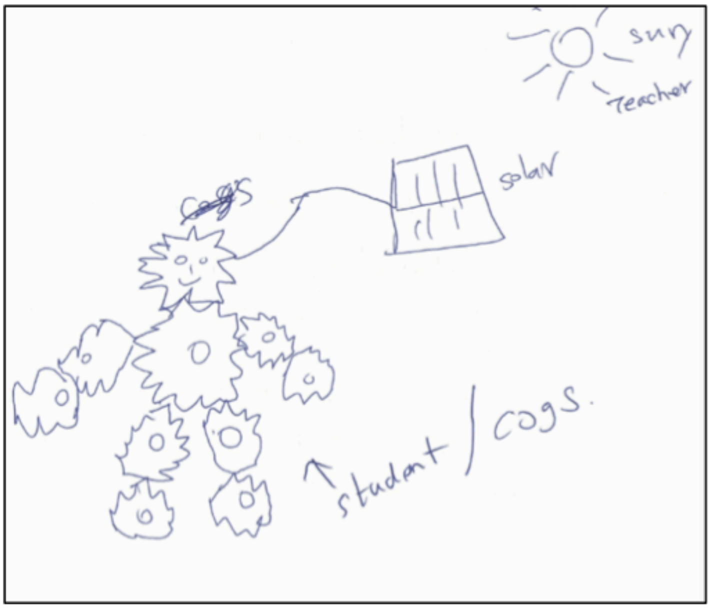

Figure 5: Teaching represented with a metaphor (male Secondary PST).
Caption: "Teachers are like the sun - who makes the cogs from the student move"

Pre-service teachers' ten-year projections

The primary and secondary PSTs were asked, "Where do you see yourself in ten years' time?" Their responses are summarised at Table 4.

Table 4: Pre-service teachers' ten-year projections

Career position/role	Primary %	Secondary %	Grad Dip %
Teaching role	80	64	72
Leadership (deputy principal)	8	19	8
Other (for example returning to previous career or another career)	6	7	11
No idea	4	5	6
No answer	2	5	3

As seen in Table 4, the majority of each PST cohort expected to be in a teaching role ten years after the study. Some of the secondary PSTs expected their teaching to be in a post-secondary setting.

> I would like to be teaching at a high school, or University level (male Grad Dip PST);
>
> In 10 years', time I hope to be teaching in a high school or researching either physics or education (male Secondary PST).

The majority of the Graduate Diploma students were still connected with their undergraduate discipline and the possibilities of those careers. Some graduate students had completed their first degree and then started a Graduate Diploma immediately after. Others had already been in the workforce and were transitioning to a new career in teaching; these PSTs generally referred to their previous careers in their responses.

> Doing something to do with either engineering or teaching or both (male Grad Dip PST).

Many PSTs saw themselves teaching in rural areas or taking their teaching to other countries and there were others who mentioned that teaching may be compatible with a family:

> Teaching abroad or Eastern Australia (female Grad Dip PST);

> Teaching either over east or abroad - hopefully with a partner, maybe family (male Grad Dip PST).

Some respondents viewed teaching as inspirational and provided comments such as:

> I will be teaching overseas, maybe science, maybe not. I want to try to inspire people/students to want to learn more themselves. (female Primary PST).

Perceived characteristics of effective science teachers

Using an iterative approach, student responses were coded into the categories shown at Table 5. We note that none of the PSTs had yet been on a professional placement.

When comparing the attributes, the primary cohort rated *confidence* and *enthusiasm* much lower that the secondary cohorts. *Knowledge* was rated at 18% for the secondary cohorts and only 8% for the primary, while *passion* and *enthusiasm* were rated 19% for the secondary cohorts but only 10% for the primary group.

Both groups rated *communication* equally at 6% primary and 7% secondary. Most of the difference occurred in *interpersonal skills* where the primary cohort expressed these as important attributes, 35% of the time, and the secondary cohorts nominated these skills at only 18%. The primary cohort indicated that *patience* was the attribute most commonly named as well as *caring*, *considerate* and *confidence*.

As illustrated in Table 5, the cohorts shared many of the same attributes. Of interest, the secondary PSTs (19%) did not view interpersonal skills as being important to the same extent as primary PSTs. Secondary PSTs rated enthusiasm and passion 20% whereas primary PSTs only considered them in 10% of the responses. It is also interesting to note that over twice the number of secondary PSTs rated knowledge as important.

Table 5: Summary of PSTs' reported attributes of effective teachers of science

Category	Attributes	Secondary %	Primary %
Knowledge	Knowledgeable, content knowledge, informative	18	8
Enthusiasm	Enthusiastic, passion, passionate	20	10
Communication	Ability to speak, good listener, good communicator	8	6
Pedagogical skills	Flexible, engaging, making it enjoyable, breaking down complex ideas to simple ones, approachable, encouraging, creative, supportive, asking the right questions	26	27
Interpersonal skills	Willing to learn, patient, confident, humour, caring, considerate, committed, persistent	19	35
Management	Fair, punctual, organised, care for and believe in students, control, able to coordinate	7	12
Other	Professional development participation	2	2

What are your three biggest concerns about being a teacher?

The reflective instrument also asked the participants about the students' biggest concerns about becoming a teacher. Responses were analysed using a modified version of Hall and Hord's (1987) *Concerns-Based Adoption Model*. Specifically, the PSTs' concerns were classified in the first instance as inward-focused or outward-focused: that is, concerns about themselves and concerns about their teaching ability. These classifications were then grouped under broader categories as summarised in Table 6.

Given that many Grad Dip PSTs were older and commencing a second career, their concerns were mapped separately from those of the B.Ed. Secondary cohort. Of interest, the Grad Dip cohort had few general school concerns (4%): that is, they expressed fewer concerns about the possibility of facing issues with parents or with their colleagues. This was a much greater concern for the secondary cohort, with 21% comments relating to concerns in this area and 13% for the primary cohort.

Thirty-one per cent of the primary cohort comments related to personal or *self-concerns*. For the B.Ed. secondary (17%) and Grad Dip (26%) these concerns were still significant. For the concerns that related to *teaching ability*, the secondary cohorts indicated a similar percentage of these teaching concerns (around 30%).

Conclusions

Envisioning science educators

The development of STEM teachers with a strong professional identity necessitates the active and explicit engagement of pre-service STEM teachers in their thinking about self, career and experience (see Beltman et al., 2015). The research presented in this paper contributes to gaining a better understanding of how PSTs see themselves as science

Table 6: Primary and secondary PSTs answers to the question "What are your three biggest concerns about being a teacher?"

Category	Classification	Examples	Secondary %	Primary %	Grad Dip %
Inform-ational	General - school	Parents, family issues that become classroom school issues, being part of an encouraging staff team, office politics, bad colleagues, social media, resources, lack of funding.	21	13	4
	General - external	Politics, economy of society, social status, not being valued.	0	2	4
Personal	Self-concerns	Making technical errors, losing my passion, burning out, not knowing science, re-learning maths, being bored, finding a job.	17	31	26
	Teaching ability	Inability to connect with students, coping with workload, how to inspire curiosity, time management.	34	21	31
Manage-ment	Classroom management	Mis-behaving kids, children who are disinterested, lacking classroom engagement.	21	21	29
Consequ-ence	Impact	Students' learning, students enjoying science and wanting to be there.	7	12	6

educators. It is our hope that the findings will inform the development of initiatives to alleviate PST's career concerns, to encourage the explicit exploration of professional identities, and to position learners so that they engage with experiential, student-centred science education pedagogy. For some students, in particular secondary PSTs, the request to draw themselves as science educators was very challenging; indeed, a number of students did not complete the drawing prompt within the reflective instrument. However, we believe that the reflective exercise in itself disrupted their dominant thinking and challenged them to conceptualise themselves as teachers.

Although this diverse group of PSTs included both undergraduate and graduate PSTs, some of whom were second careerists, many of the characteristics and concerns they expressed were similar. As a cohort, the PSTs felt that effective educators were passionate, patient, knowledgeable and confident, and they used descriptors such as *approachable*, *fun* and *engaging* when describing themselves in their own classroom. Pre-service teachers from all three student cohorts expressed a range of concerns from personal concerns to concerns about managing the behaviour of students and interacting effectively with their colleagues.

Primary PSTs were less rigidly bound to the traditional classroom spaces of tables and chairs than the secondary and Grad Dip PSTs. It would seem that the secondary and

Graduate Diploma PST's reinforce the stereotype of a teacher as the 'sage on a stage', which is perhaps more common in secondary school settings.

The majority of all PSTs also saw themselves in a teaching or a teacher leadership role ten years after graduating, suggesting that they planned a mid or long-term career engagement in teaching, but not necessarily in the classroom. Many authors who have previously worked with pre-service teacher drawings report that students' drawings are incongruent with the nature of teaching (e.g., Beltman et al., 2015). It is important that this lack of congruency be addressed so that pre-service teachers develop a realistic expectation of teaching and are able to develop a teacher identity that is resilient, agile and robust.

Concerns of pre-service science teachers

Similarities in the concerns expressed by each cohort might relate to the fact that none of the students had yet been on a practicum and therefore had little or no classroom experience. Secondary PSTs expressed far more concerns about aspects such as working with colleagues and managing parents than did their Grad Dip peers. It is possible that the Grad Dip cohort, who were slightly older, had greater experience of managing people and working with teams within their previous careers; it is also possible, given that the Grad Dip PSTs were in only the first few weeks of their teacher training, that they had not yet thought about these concerns!

Discussion

This project presents a snapshot of the reflective thinking within a cohort of primary and secondary science PSTs. The findings suggest that, at this (pre-practicum) stage in their initial teacher education training, students might view teaching as a long-term career chosen with enthusiasm in anticipation of the potential to change the lives of the students in their care. We note that most of the pre-service teachers are relying on previous life history to help them identify what is important as a teacher/science teacher. Future research might seek to monitor science students' thinking longitudinally to understand whether and, if so, why this enthusiasm wavers. Future research might also explore whether and how PSTs change their view of themselves as a teacher of science through their initial teacher education and beyond. This might be achieved with semester or annual surveys, ideally continuing post-graduation. We believe this to be a crucial action in order to halt the exodus from an area of significant importance.

We reflect that the B.Ed. Primary cohort may struggle to develop a science teacher or, more accurately, a 'teacher of science' identity, as they may think of themselves as teachers of children rather than as teachers of science. In this study, the B.Ed. Primary PSTs were predominately second-year students who were developing their identity as university students *and* as pre-service teachers. Drawing on the work of Devitt, Kerin, and O'Sullivan (2012), we speculate that these students are at present too far from the threshold of their chosen profession and therefore articulate a more personally focused set of concerns; the personal persona orientation of their drawings would support this hypothesis. The Grad Dip students were within months of crossing the threshold from student to professional. Many of the students were already professionals, with identities based in their previous fields of STEM-related work. We propose that these students might hold divergent identities. An interesting avenue for future research would be to map students' science and developing teacher identities side-by-side.

The secondary cohort in our study were in the second year of a four-year degree and so equally focused on student life and life as a teacher. The students were all studying compulsory content units taught outside the School of Education. These included biology units in the Faculty of Health Sciences, economics units in the Faculty of Business and Law, and chemistry and physics units in the Faculty of Science and Engineering. It is possible that students' concerns about knowledge content relates to being with the science major students; indeed, it is possible that these students were conflicted in their identity as they participated in *both* science specialist and teaching specialist communities and yet in neither community all of the time. It is also possible that these students experienced tensions between typically behaviourist, traditional teaching in their science studies and the modelling of pedagogical expertise which typifies their teacher education classes.

Devitt et al., (2012, p. 131) contended that "it is the development of student teachers' identities as professionals which is perhaps more critical to successful negotiation of the liminal space between student and professional within which they find themselves". The authors describe this liminal space as *troublesome* as well as *transformative*. We add that there is significant turbulence as students seek to travel the road from novice and student to professional and teacher, and in some cases from scientist to teacher or fusing a hybrid of the two as a teacher of science.

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Dr Rachel Sheffield is Associate Professor in School of Education at Curtin University, Australia and a member of the Executive of Curtin Academy. She researches and publishes in science, STEM education and professional identity. Rachel has won Faculty, University and national awards for teaching excellence and an Executive Endeavour Fellowship.
Email: rachel.sheffield@curtin.edu.au
Web: https://staffportal.curtin.edu.au/staff/profile/view/Rachel.Sheffield/

Dr Susan Blackley is currently seconded to the Faculty of Humanities Director of Student Engagement position at Curtin University. She researches and publishes in STEM education and professional identity development and the use of digital professional portfolios to support this development. Susan is a Curtin Fellow, a Senior HEA Fellow and a HERDSA Fellow.
Email: susan.blackley@curtin.edu.au
Web: https://staffportal.curtin.edu.au/staff/profile/view/Susan.Blackley/

Professor Dawn Bennett is Distinguished Professor of Higher Education with Curtin University, where she directs the EmployABILITY thinking and creative workforce initiatives. Dawn's research focuses on the development of employability. She is currently operationalising a free metacognitive model for employability (https://developingemployability.edu.au) with faculty and students at multiple institutions. Publications appear at Researchgate. (https://www.researchgate.net/profile/Dawn_Bennett)
Email: dawn.bennett@curtin.edu.au
Web: https://research.curtin.edu.au/researcher/dawn-bennett-10f9ee67/

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