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Preservice teachers' self-efficacy to teach primary science based on 'science learner' typology

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ABSTRACT

According to international benchmarks [Thomson, S., Wernert, N., O'Grady, E., & Rodrigues, S. (2017). TIMSS 2015: Reporting Australia's results. Retrieved from Camberwell, Victoria: www.acer.edu.au/timss], Australia's science education is still in decline and so the need for further investigation into preservice teachers is warranted. Utilising data from a broader mixed methods doctoral study [Norris, C. M. (2017). Exploring the impact of postgraduate preservice primary science education on students' self-efficacy. Retrieved from http://ro.ecu.edu.au/theses/2040], this paper investigates the type of science learner entering into postgraduate preservice primary teacher education and how different learner types influence teacher self-efficacy and their effectiveness to teach science [Bleicher, R. (2009). Variable relationships among different science learners in elementary science-methods courses. International Journal of Science and Mathematics Education, 7(2), 293–313. doi:10.1007/s10763-007-9121-8]. In this study, data was derived from a modified STEBI-B questionnaire and focus group discussions that provided a deeper insight into the survey data. Participants ($N = 274$) were from a one-year Australian Graduate Diploma of Education Primary (GDEP) program. Bleicher's (2009) research on 'science learner types', which included Fearful, Disinterested, Successful and Enthusiastic learners, was used as a theoretical framework to categorise the participants. The study identified a new type of learner (Not Clearly Identifiable, $n = 68$), located in the middle of the other four categories, where individuals' attitudes and beliefs towards science had changed due to life experiences between secondary school and their GDEP program. Statistical analysis showed science learner types did influence participants' science teaching self-efficacy (STSE), giving suggestions for how this may affect tertiary teacher education courses.

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Self-efficacy; *type* of science learner; primary science; preservice teacher training; science teaching

Introduction

The quality of preservice primary science education is a concern raised by researchers (Appleton, 2003; Deehan, Danaia, & McKinnon, 2017; Hackling, 2014; Velthuis, Fisser,

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& Pieters, 2014) who examine international science and mathematics global competitiveness via assessment processes Trends in International Mathematics and Science Study (TIMSS) and The Programme for International Student Assessment (PISA).

The Australian Institute for Teaching and School Leadership (AITSL) expects professional competency by teachers to 'know the content and how to teach it' (AITSL, 2017). However, Lederman and Lederman (2015) emphasised that differing contextual and political issues also impact science teaching and therefore, it is difficult to have one approach to quality pedagogy across Years K-12. Having flexible approaches to science education means developing appropriate subject (SCK) and pedagogical (PCK) content knowledge (Shulman, 1986), along with self-efficacy in teaching primary science (Gibson & Dembo, 1984; Bleicher, 2009). The notion of primary science teaching self-efficacy is considered an important part of developing quality teaching, as low self-efficacy is often seen as a major obstacle to effective primary science teaching (Gunning & Mensah, 2011; Menon & Sadler, 2016). Therefore, researchers (Bleicher & Lindgren, 2005; Velthuis et al., 2014; Menon & Sadler, 2016) see science teaching self-efficacy as a continuing concern for all preservice teacher education providers.

Primary science education is to foster sustained and positive student interest in science, and to ensure that emerging conceptual understanding are grounded in evidence-based inquiry that can challenge scientific misconceptions (Duit & Treagust, 2003). Consequently, the concrete operational stages of learning in the primary years are essential for capturing students' interest in science (Bybee et al., 2006; Fitzgerald, Dawson, & Hackling, 2013; Preston & Skamp, 2015). However, research has shown that primary teachers are reluctant to teach science (Appleton, 2003; Fitzgerald et al., 2013). Therefore, it is essential that teacher education providers reduce the level of fear of science that many generalist primary teachers often have (Bleicher, 2009; Bergman & Morphew, 2015) in an effort to improve science teaching and engagement of students in science, through increasing teacher self-efficacy. This in turn may lead to meeting the aims of primary science education through utilising engaging pedagogical strategies when teaching primary science.

Along with low science self-efficacy (Gibson & Dembo, 1984), research has identified further barriers associated with primary science teaching. These include primary teachers having low confidence in their ability to teach science as well as identifying a limitation in their science content knowledge (Enochs & Riggs, 1990; Howitt, 2007; Menon & Sadler, 2016). Furthermore, Bleicher (2009) identified the type of science learner a person may be during their secondary science education experiences as an additional barrier to teaching of science. Of all these barriers, the literature suggests that type of science learner and its impact on self-efficacy has not been investigated in the context of postgraduate primary teacher education courses. Therefore, this study focussed on the effect of the type of learner on preservice teachers' self-efficacy within an Australian GDEP science education unit, to further understand the factors that influence self-efficacy in teaching science. This gap in the literature forms the basis for exploring the following research questions:

- Who are our postgraduate primary science preservice teachers in terms of 'types of learners'?
- Does the type of science learner impact preservice teachers' science teaching self-efficacy?

Theoretical framework

TIMMS report shows that there is still a disparity between the idealistic notion of learning and teaching in science education, and the actuality of this in Australian schools (Martin, Mullis, Foy, & Hooper, 2016). The Australian Curriculum Assessment and Reporting Authority (ACARA, 2017) and the Australian Institute for Teaching and School Leadership (AITSL) (2017) (require deep learning of science concepts and skills. However, Australian TIMSS statistics claim that the required TIMMS science topics may have been taught to only 61% of Year-4 students and 59% of Year 8 students during or before the relevant year (Thomson, Wernert, O'Grady, & Rodrigues, 2017). Furthermore, the TIMMS statistics showed that in Australia most children are taught by a generalist primary teacher (77%) without any major specialisation in science, compared to the highest performing country, Singapore where only 17% are generalist primary teachers and 69% are science specialist trained (Martin et al., 2016). These statistics could infer a correlation between reduced numbers of teachers with science specialist SCK and PCK and reduced time spent teaching primary science (Martin et al., 2016). Deehan et al. (2017) posit that the TIMSS scores continue to suggest that primary teachers in Australia are still "broadly failing to develop the scientific literacy of their students" (p. 2549).

A primary school teacher is the first formal education influence on young children, making their role pivotal to the development of learning and teaching of science (Fitzgerald et al., 2013). Research of in-service primary teachers has shown that many feel uncomfortable teaching science or that they are not prepared to teach it due to low self-efficacy in science (Bergman & Morphew, 2015; Howitt, 2007). This culture may continue to be perpetuated by preservice teachers who have had a negative experience with science learning. Research has shown that teachers with low efficacy may avoid teaching science (Velthuis et al., 2014) or using unengaging and didactic approaches (Avery & Meyer, 2012; Smith, Goodrum, Druhan, & Heard, 2011).

It has been found that a teacher's attitude, be it positive or negative, towards science can easily transfer to their impressionable students; thereby influencing their students' attitude and engagement with the subject (Bergman & Morphew, 2015). Further research has found that by the age of 14 a student's attitude towards and engagement with science tends to be developed (Fitzgerald et al., 2013). This again underlines the importance of ensuring that initial science education must be a positive and engaging experience, led by a teacher who is also confident and positive in their attitude towards science. These attitudes and experiences may therefore shape the science self-efficacy of those who are training as preservice teachers (Avery & Meyer, 2012; Cantrell, Young, & Moore, 2003).

Self-efficacy and primary science teaching

Cronje (2011) posits that a teacher's commitment is based upon the values they hold, attitudes towards a subject and confidence to deal with unfamiliar issues. Both in-service and preservice teachers are constantly faced with new situations where their resilience and the motivational construct of self-efficacy to teach subject content will directly influence student outcomes (Bandura, 1977; Bergman & Morphew, 2015; Pendergast, Garvis, & Keogh, 2011). Hence, self-efficacy to teach primary science (Bergman & Morphew, 2015; Enochs & Riggs, 1990; Palmer, 2006) is considered an important construct that needs a central place in designing and delivering tertiary primary science education units.

Rotter (1966) first developed the notion of self-efficacy, whereby an individual's internal or external loci of control will impact their self-efficacy (McKinnon & Lamberts, 2013). Bandura (1977) suggested that social learning theory will also form an individual's efficacy expectation, their outcome expectancy and self-belief in their capabilities, shaping behaviour in order to achieve a favourable outcome. These behaviours include demonstrating perseverance and resilience to problem solve in order to achieve personal goals, even in adverse conditions (Bandura, 1977). This makes the notion of self-efficacy context-specific and distinguishable from self-esteem (Morrell & Carroll, 2003; Pajares, 1996; Tschannen-Moran, Woolfolk, & & Hoy, 1998). In the context of education, Tschannen-Moran et al. (1998) define teacher self-efficacy as "the teacher's belief in his or her capability to organise and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233). The formation of self-efficacy is triadic in its approach, shaping an individual's performance through the interaction of factors such as personal, environmental and behavioural influences (Bandura, 2012). Therefore, preservice teachers' teaching self-efficacy in one learning area may differ from another (Lummis, Morris, & Paolino, 2014). Teacher education has a crucial role in developing self-efficacy, as it is an environmental determinant. A fear of science and negative attitudes towards science, developed at an earlier time in a student's education, will shape a preservice primary teacher's self-efficacy to learn and teach science (Avery & Meyer, 2012; Bleicher, 2009; Mulholland, Dorman, & Odgers, 2004; Palmer, 2006).

Type of science learner

As mentioned earlier, preservice teachers enter science education units with varying levels of self-efficacy shaped through the different levels of science content knowledge and their learning experiences (Bleicher, 2009; Howitt, 2007; Lederman & Lederman, 2015; Mulholland et al., 2004). Preservice primary teachers often enter science education courses with inadequate science content knowledge and negative attitudes towards learning science (Bleicher, 2009; Bleicher & Lindgren, 2005). Bleicher (2009) investigated the notion of behaviour and attitude associated with science, as an indicator of the type of science learner a preservice teacher would be. Bleicher's research was conducted with undergraduate preservice teachers and four types of science learners were identified when participants disclosed their prior science learning experiences. These types were: *fearful of science*; *disinterested in learning science*; *successful in science,* and *enthusiastic about science.*

Research into 'learning styles' (Hattie, 2009; Pashler, McDaniel, Rohrer, & Bjork, 2009) reinforces that 'learner types' are not to be confused with learning styles. Learning styles can refer to the mode of instruction or study that students find most effective to use (Pashler et al., 2009); whereas learning types refers to an individual's confidence in the subject matter (Bleicher, 2009) and may influence both self-efficacy and attitude towards the subject area.

Methods

Research context

Research into undergraduate primary teacher education has emphasised its essential role in preparing quality teachers through the development science teaching self-efficacy

(Mulholland et al., 2004; Rice & Roychoudhury, 2003). While Bleicher's (2009) research on learner types used undergraduate participants only, this paper further aimed to explore learner types and its impact on self-efficacy within a cohort of postgraduate students. All Graduate Diploma of Education Primary (GDEP) participants were enrolled in a primary science education unit where both science SCK and PCK were delivered. The unit ran for 10 weeks in a three-hour tutorial format. The tutorials were structured as interactive lectures and hands-on inquiry based investigations, modelling teaching and learning strategies that could be employed in the primary science class. The unit was delivered by a number of tutors utilising the same unit material developed by a unit coordinator. Although the same unit materials were disseminated to all participants, each tutor was encouraged to implement materials in a way that best meet the needs of their students.

Design

The broader doctoral research (Norris, 2017) used a concurrent embedded mixed method design, which can be defined as the concurrent collection of rich data from both qualitative and quantitative methods without bias towards either method (Creswell, 2014; Tashakkori & Teddlie, 2010). This design provided a more comprehensive overview of the phenomena than a single method design (Menon & Sadler, 2016; Morse & Niehaus, 2009), and was appropriate due to the complexity of the constructs; namely science teaching self-efficacy and its relationship to factors such an individual's prior science learning experiences or type of science learner they are.

Both qualitative and quantitative data were collected in a traditional pre and post-test survey that included text response questions along with a quantitative modified STEBI-B instrument (Creswell & Plano Clark, 2011). Further data were obtained through focus group discussions, providing insights into participant attitudes, opinions and perceptions (Ogunbameru, 2003). While there was not an intentional instrument used to elicit type of science learners, as in Bleicher's (2009) research, the item '*briefly describe your own science learning experiences*' and transcription data from focus groups did elicit responses that were able to be categorised into types of science learners. The qualitative method allowed for the 'unearthing' of an additional category in comparison with Bleicher's (2009) study that allowed the relationship between types of science learner and self-efficacy to be explored in this paper.

Data collection and analysis

Participants ($N = 371$) were administered a pre-test survey which included both qualitative and quantitative instruments to elicit background and self-efficacy data. This initial background information allowed for the analysis of the GDEP cohort's type of science learning. A post-test instrument, STEBI-B was again administered to measure post-test self-efficacy data ($N = 274$). The qualitative data described in the survey was supported through pre and post-test focus group discussions. The data were then linked with pre and post-test quantitative self-efficacy data to identify possible relationships between the two sets.

The modified STEBI-B

A modified Science Teaching Efficacy Belief Instrument B (STEBI-B) was used to measure self-efficacy for primary school science teaching of preservice teachers (Enochs & Riggs, 1990). The STEBI was designed by Enochs and Riggs (1990) specifically to measure the generalist primary teachers' self-efficacy of science teaching as they considered there to be varying efficacies between subject areas. This instrument measured the two constructs of self-efficacy on a 5-point Likert scale (Burns, 2000). These constructs are Personal Science Teaching Efficacy Belief (PSTE), measuring participants' belief in their own ability to teach science effectively (Deehan et al., 2017) and Science Teaching Outcome Expectancy (STOE), measuring the participants' broad view of how the teaching of science impacts the pupils' level of learning (Enochs & Riggs, 1990). In the broader study (Norris, 2017), a Pearson's correlation coefficient found there to be a small interaction between the two self-efficacy constructs of STOE and PSTE ($r = .260$, $N = 272$, $p < .001$) indicating these latent constructs act largely independent from each other. This result was supported by Enochs and Riggs's (1990) findings; therefore, it was valid to analyse each construct independently.

This instrument has been used in various studies (Bleicher, 2009; Cantrell et al., 2003; Mulholland et al., 2004) with results supporting the validity and reliability of both constructs, with the original authors reporting Cronbach's ∝ coefficients of 0.90 and 0.76 for the PSTE and STOE constructs respectively (Enochs & Riggs, 1990). The same modified STEBI-B as used by Deehan et al. (2017) also reported Cronbach's α coefficients of 0.88 for PSTE construct and 0.87 for STOE constructs.

Using the principle of parsimony (Epstein, 1984), a confirmatory factor analysis was used to minimise the number of items on each construct to allow for validation of the instrument used in this contextual study. Similar to Enochs and Riggs (1990), the internal consistency of the STOE and PSTE constructs in this study's modified STEBI were found to be Cronbach's $\alpha = .75$ and .90, respectively. The modified STEBI had eight items on each scale, with a maximum total score of 40 per construct. Consequently, the scores of STOE and PSTE were comparable and used to analyse data in relation to the varying types of science learners.

Survey and focus group data

Pre and post-test focus group discussions, where participants verbalised their secondary school science learning experiences, provided data that were interpreted and coded. The focus group data were matched with each individual's survey data, allowing for deeper investigation and validation of interpretation by the researcher when coding (Creswell & Plano Clark, 2011; Ogunbameru, 2003). The use of Bleicher's (2009) semantic analysis provided a basis for the identification of similar themes and served as a test of validity (Deehan et al., 2017). Using Bleicher's (2009) descriptors the cohort's descriptions of science learning experiences are categorised in Table 1.

Findings

Participant 'Learner type' data

Table 2 shows the distribution of participating preservice teachers' types of learners, as outlined by Bleicher (2009). Participants were coded to a category based on their written responses. These data only include those who participated in both pre and post intervention surveys in order to allow comparison of pre and post self-efficacy scores with learner type.

Table 2 shows only a small proportion of participants were truly *fearful* of science, and many were either *enthusiastic* or *successful* in science. Contrary to other Australian studies with undergraduate primary preservice teachers (e.g. Deehan et al., 2017; Mulholland et al., 2004), most participants (77%) in this cohort had completed a senior secondary science subject. A total of 33% had continued into a tertiary undergraduate degree with science components, while 7% had completed a science postgraduate degree, which may account for the low number of *fearful* participants.

Table 2 also shows an anomaly in the total percentage, as both written and verbal data revealed an additional category of type of learner that did not fit within Bleicher's (2009) defined categories. This new category represented 24.8% of the cohort, and included participants who:

- Had varying secondary science experiences, both positive and negative, depending on which science strand was taught. For example, positive biology experiences and negative physics learning experiences;
- Changed their attitude towards science learning and understanding concepts as they may have disliked science in secondary school education however, due to adult life experiences or having school-aged children themselves have shown to appreciate and enjoy science.

As this category included conflicting attitudes about science it was labelled as *not clearly identifiable* (NCI). This was demonstrated through comments such as:

- "I completed biology studies throughout high school and enjoyed that area of study. Physics and chemistry; however, were areas I never particularly enjoyed";
- "Found science very difficult to grasp at school. Played sport and ran a fitness consultancy, which through various qualifications began to increase my scientific knowledge

Table 1. Type of science learners and their characteristics.

Type of science learner	Characteristics
Enthusiastic	Strong statements expressing their high interest in science; enjoyed science classes they had at secondary school; attended extra-curricular science *type* of activities or hobbies; not necessarily achieving highest grades in classes other than science and commented that they are looking forward to teaching science.
Successful	High achievers in the area of science academic classes along with other learning areas; didn't comment on specific science hobbies or specific interest outside of school science; felt confident to learn and understand science concepts.
Disinterested	Stated they had a dislike or disinterest for science during their secondary education. They reported feeling bored, not engaged during class and described having to rote learn or memorise large amount of information in order to pass an assessment. They did not mention that they were worried or afraid of science learning and often did well in class despite the disinterest in the subject.
Fearful	Mentioned that they were afraid or had apprehension towards science. They did not enjoy science activities and often mentioned that the subject content felt *foreign* and did not make sense. They mentioned struggling to pass the subject and did not feel confident about teaching science even at the commencement of the unit due to their lack of conceptual understanding.

Table 2. Percentage of participants per type of learner.

Type of learner	Participants (%)	Example of anecdote
Enthusiastic	31.4	'I was part of academic talent program for science' 'Enjoyed anything to do with the physical sciences immensely'. 'I have a strong understanding and enthusiasm for science, research and critical thinking'.
Successful	15.3	'I have always been comfortable with the sciences'. 'I studied physics, chemistry at Year-12 and performed well in both these subjects'.
Disinterested	17.9	'Wasn't particularly interested in science but didn't hate it' 'Hate doing experiments'
Fearful	10.6	'Science was one of my most challenging subjects at school and I struggled through to pass. I have spent my life/career avidly avoiding anything remotely scientific!' [I was] scared of science, did not connect with it, so felt like my brain was not 'wired for it'
Total	75.2	

Note: Total number of participants $N = 274$. Distribution based on interpretation from characteristics as per Bleicher (2009).

of the human body. Began learning planets through my 6-year-old son in last year"; and

- "I believe that science is part of my day to day life, [like] learning a new recipe."

Self-efficacy of the postgraduate participants

As the latent variables of PSTE and STOE are two separate constructs, each of these are reported on separately. A one-way ANOVA was conducted to determine if there was an effect on a student's self-efficacy through participating in GDE-P tutorials.

The PSTE results, Wilks' Lambda = .833, $F(1,271) = 54.41$, $p < .001$, indicating a significant effect pre and post-test. A Cohen's d effect size was calculated as $d = 0.41$ ($N = 272$), which is considered as a small-medium (Cohen, 2013; Coe, 2002) positive change indicating that the participants had increased their self-belief to teach primary science.

The STOE results also indicated a significant effect, Wilks' Lambda = .853, $F(1,271) = 46.78$, $p < .001$. A Cohen's d effect size was calculated as $d = 0.38$ ($N = 272$), which is considered a small effect (Cohen, 2013; Coe, 2002), indicating that there was a small increase in their science outcome expectancy belief after participating in the tutorials.

Type of science learner and their teaching self-efficacy

As the two self-efficacy constructs of PSTE and STOE showed divergent validity, the following section outlines how the various types of learners may have influenced each construct separately.

Personal science teaching efficacy

Figure 1 demonstrates that all science learner types had an increase in their post PSTE after completing the GDEP unit. The magnitude of each increase varies, with the greatest change being found in *fearful* type learners.

This finding was supported through conducting a one-way MANOVA. This revealed a significant multivariate main effect of science learner types on the pre and post PSTE intervention scores (Wilks' Lambda = .843, F (8,400) = 4.446, $p < .001$, partial eta squared = .082; power to detect the effect was .996).

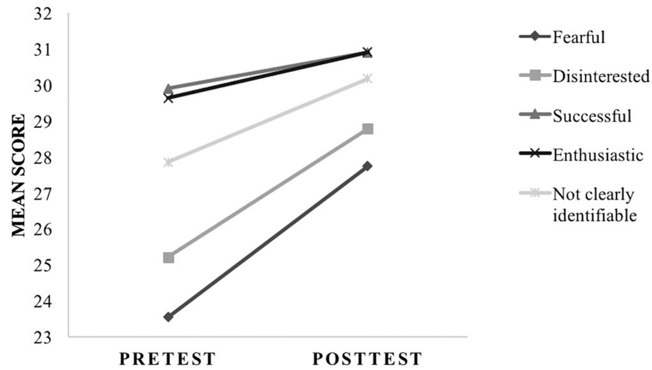

Figure 1. Mean scores of types of learners' PSTE pre and post-test.

Due to the significance of the MANOVA, the variation magnitude of the types of learners was determined through a Tukey HSD post hoc test. Table 3 shows significant differences between the learner types.

There were significant differences between *successful/enthusiastic* and *fearful* type learners, as well as *successful/enthusiastic* and *disinterested* type learners. The *fearful* category was also found to be significantly different to the *NCI* category. These results confirmed the types of learners are discrete categories. There are particularly significant differences between categories that are more positive (*enthusiastic* and *successful*) compared to more negative categories (*fearful* and *disinterested*). The level of significance of the comparison between *fearful* and *NCI* groups was less than the others. This may indicate that the *NCI* group's perceptions of science are such that they don't fear the subject but may have other reasons for wanting to engage or not engage in science.

In comparison to the pre-test PSTE results, the post hoc analysis of post-test PSTE with Tukey HSD (using an α of 0.5) only demonstrated statistical significance between the *enthusiastic* and *fearful* groups. This may indicate that the intervention of the design or teaching of the unit has improved the self-perception or attitude towards the teaching of science for those who were categorised as *disinterested* or *fearful* learners. The improvement brings the values closer to those that had higher self-efficacy in their ability to teach science. A non-significant result between the *successful* and *enthusiastic* groups may suggest a possible ceiling effect in their PSTE results, particularly as the pre-test was also non-significant for these categories.

The qualitative data from the pre/post-test focus group discussion supported the quantitative findings, demonstrated through comments such as:

> Prior to the unit, I had little confidence in teaching science to children. Now, it excites me! There are so many resources available, so many fantastic experiments and so many opportunities to be creative. Bring it on!

and

> I was not confident with science but now it feels much more achievable. Still feel now it will just be time/experience to make me a good science teacher. I feel I have a good "toolkit" to start after this unit.

Table 3. Significant Tukey HSD post Hoc multiple comparisons pretest PSTE means.

					95% Confidence Interval	
(I) type of learner	(J) type of learner	Mean difference (I-J)	Std. error	Sig.	Lower Bound	Upper Bound
Successful	Fearful	5.93	1.355	.000	2.20	9.66
	Disinterested	4.21	1.193	.005	.93	7.50
Enthusiastic	Fearful	5.75	1.186	.000	2.48	9.01
	Disinterested	4.02	0.998	.001	1.28	6.77
NCI	Fearful	3.84	1.231	.017	0.45	7.23

Note: Based on observable means. The error term is Mean Square (Error) – 18.242.
$p < 0.05$.

Science teaching outcome efficacy

An individual's belief of their effectiveness as a science teacher may also be affected by the type of science learner they are. The following Figure 2, demonstrates the changes for the type of learners' STOE pre and post participation in the GDEP unit.

A statistical analysis on the pre and post STOE scores indicated that the type of learner did not have an influence for a significant change. This can be supported by a visual analysis of Figures 1 (PSTE) and 2 (STOE) which showed much less change in the participants' STOE values, in comparison to their PSTE values.

Using qualitative data, it could be surmised that those classified as *fearful* learners still had a feeling of anxiousness about their effectiveness as a teacher of science due to lack of science concept knowledge, even after participating in the unit. One *fearful* participant mentioned that there were petrified, yet also felt "*very interested to incorporate it* [science] *into my teaching*" after the unit. These comments could indicate that although they felt they had improved in their self-belief to understand science, they still struggled with their confidence to teach science. Another *fearful* learner stated they "*really struggled with science*" during the initial focus group discussion, however there seemed to be an attitudinal change in the post focus group discussion whereby they commented, "*I believe science can be taught in a very engaging manner and that students will love it*". This participants STOE score had increased after participating in the unit, which may indicate that their experience had been positive. An *enthusiastic* participant demonstrated their enthusiasm for science through mentioning they enjoyed their high school science classes and

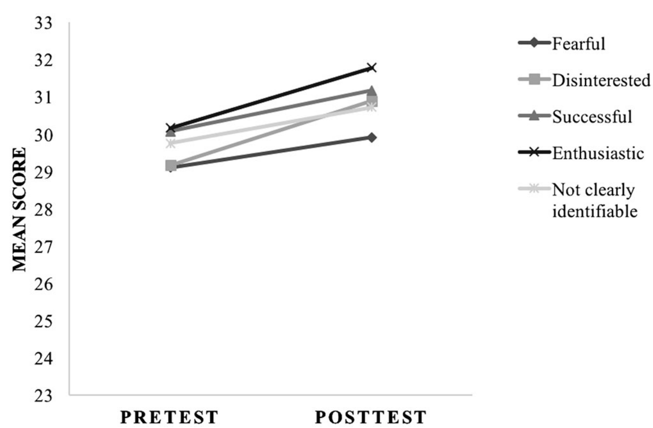

Figure 2. Mean scores of types of learners' STOE pre and post test.

had *a fascination with an undertaking private reading and experiments in electronics, magnetism, acoustic theory, chemistry …* . This participant had high pre PSTE and STOE scores with little change in their post scores. This may be a case of demonstrating a ceiling effect with these type of learners as their participation in the unit may not have had a direct influence on affecting their efficacy. The participant mentioned that the unit provided resources for future teaching experiences, through comments such as *the use of practical examples can be applied to a classroom setting, and active participation in the student role was the most useful.* Another observation was a participant who was classified as *successful* science learner, with a post graduate science related degree, demonstrated an increase in their PSTE but not STOE. Their vignette supports the increase in PSTE as they have *a bigger appreciation for the misconception side of things … making sure* [*to*] *use correct language in science*; yet they still maintain *my confidence in teaching science hasn't changed, I'm still pretty confident* supporting the lack of change in their STOE score.

The significance of the intervention for each type of learner was determined through a paired (pre and post-test) samples t-test. Table 4 indicates the significance level for each of the type of learners.

The data show an increase in the post-test scores for all learner types and self-efficacy constructs, except the STOE for the *fearful* group. Together with the high non-significance, this could suggest that the *fearful* group continue to have low self-efficacy in their belief that they will make a difference to students' science learning outcomes, even though the experience in the tutorials had increased their personal belief that they are capable of teaching primary science. The non-significance values of the *successful* group may indicate the ceiling effect as many stated that they felt confident in their science ability, and therefore this may be translated to being confident to teach this subject as well.

Type of science learner and their overall self-efficacy

A common theme was found among *fearful* type science learners, whereby they had the lowest change in STOE by a significant change in PSTE. The vignette data supported this by some mentioning that "*whilst I enjoyed each activity, I am not yet as confident as I would like with the science understanding*" linking this to low self-efficacy.

The *disinterested* learners demonstrated, in general, a greater change in their self-efficacy and improved attitude towards science. Vignette data supported this as many attributed this positive change to the practical and interactive design of the unit making it 'enjoyable' to attend. However, even within this group there were those that became overwhelmed by the amount of science content learning, which was demonstrated through comments such as … *the more I learn, the more confident I'll be … but the more I learn the more I realise I do not know.*

Some of the *enthusiastic* and *successful* participants mentioned that due to their confidence and enthusiasm in science they believed it would be easy to teach primary level science. Vignette data showed that participating in the GDEP unit, did change some of their attitude towards primary teaching as they found that this is a complex area to teach in and that their expectations were unrealistic, leading to a slight decrease in the self-efficacy scores. However, the overall post-test self-efficacy scores for both *enthusiastic* and *successful* learning styles were still high in comparison to other learning styles. This

Table 4. Paired Samples Test for each type of learner (pre/post-test).

	Paired differences							
				95% CI				
	Mean	SD	SEM	Lower	Upper	*t*	df	Sig. *
Enthusiastic								
PSTE	−1.164	3.983	0.487	−2.136	−0.093	−2.392	66	0.020
STOE	−1.806	2.664	0.325	−2.456	−1.156	−5.548	66	0.000
Successful								
PSTE	−0.957	4.552	0.831	−2.667	0.733	−1.163	29	0.254
STOE	−1.067	3.205	0.585	−2.263	0.130	−1.823	29	0.079
NCI								
PSTE	−2.491	4.223	0.580	−3.655	−1.327	−4.294	52	0.000
STOE	−1.208	2.720	0.374	−1.957	−0.458	−3.232	52	0.002
Disinterested								
PSTE	−3.027	5.325	0.875	−4.803	−1.251	−3.457	36	0.001
STOE	−1.649	2.801	0.460	−2.583	−0.715	−3.580	36	0.001
Fearful								
PSTE	−3.727	3.795	0.809	−5.410	−2.045	−4.607	21	0.000
STOE	−0.273	2.097	0.447	−1.203	0.657	0.657	21	0.548

Note: CI = confidence interval; SEM = Standard Error Mean; PSTE = personal science teaching efficacy; STOE = science teaching expectancy outcome.
*$p < .05$, two-tailed.

may indicate these scores were capped through a ceiling effect as only a marginal change in their self-efficacy was achieved. The *enthusiastic* learners' data demonstrated that this group are more likely to have the highest change in their STOE beliefs rather than in their PSTE belief. This could be attributed to confidence in their science understandings, with participation in tutorials possibly influencing an increase in their pedagogical content knowledge.

Discussion

The study supported Bleicher's (2009) research whereby prior science learning experiences (i.e. secondary science education) of preservice teachers did impact upon what type of science learner they had become. In addition to Bleicher's (2009) four categories the addition of a fifth category was identified and labelled as *not clearly identifiable*.

The findings of *fearful learners* supported those found by Bleicher (2009), where this group of postgraduate students were least confident in their ability to learn science. This study highlighted that although the PSTE and STOE scores were lower than other groups, these participants had the greatest increase in their PSTE post-test scores. The qualitative findings suggested consistency with Bandura's (1977, 2012) triadic nature of self-efficacy, whereby the tertiary experience (the 'environmental factor') supported the individual's building of confidence (the 'personal factor') and perhaps changed their attitude (the 'behavioural factor') towards science. For example, the influence on a student's attitude by the tutor could be demonstrated through the following comment: [the] *tutor was a brilliant teacher and her passion for science is obvious. This is contagious.* The following comment highlighted the change in an individual's personal factor by the unit's design: *I am not great at science but after this unit I am confident I will be able to teach engaging lessons.* The STOE scores for *fearful* learners showed little change, underscoring a potential lack of confidence in GDEP participants' ability to effect change on student learning. This phenomenon is not unusual and was found to have similar effects in self-efficacy research in other fields, such as the Arts (Lummis et al., 2014), where STOE increases as teachers gain more experience. Therefore, it is important that designers of tertiary GDEP science education units consider ways to support students to increase their STOE; perhaps through the inclusion of vicarious experiences that allow *fearful* preservice primary teachers to develop further subject content knowledge within authentic primary PCK frameworks (ACARA, 2017).

Converse to *fearful learners* were the *enthusiastic learners*, whose PSTE and STOE scores were consistently higher than the other groups. Although not significant, in comparison to the other groups these learners had the highest increase in their STOE. It is likely their prior positive learning experiences contributed to a high PSTE, yet they were receptive to learning the importance of a teacher's role in their future students' education and therefore increased their STOE (Bandura, 1977; Mulholland et al., 2004).

Consistent with Bleicher (2009), there was no statistical significance between GDEP students who were *successful* and those who were e*nthusiastic* science learners in their response to their PSTE and STOE. Although Bleicher (2009) suggests these categories be grouped for analysis, it is interesting that quantitative analysis clearly separates these GDEP students; where the *successful* group had no statistical significant change on their pre/post test scores, compared to the *enthusiastic* group's statistical significance on STOE. This may indicate that it is the *successful* group that creates the ceiling effect and not the *enthusiastic* group. There seemed to be a distinction in the qualitative data as well, whereby the *enthusiastic* group enjoyed science, yet did not necessarily achieve success easily. The conflation of these two groups may in fact limit the delineation and depth of understanding of individuals within a GDEP cohort.

Those who were in the *disinterested* group offer an important dimension. Although a participant's confidence to learn science may be undermined by a lack of interest towards the subject (Dewey as cited in Bleicher, 2009); this study found the *disinterested* category of participants to be both engaged and enthused throughout the learning experiences. The engagement was evidenced by a statistically significant increase in PSTE and STOE, which suggested an attitude and belief change within this group of participants. This outcome supported Bleicher's (2009) notion that a *lack of interest* does not equate to *lack of confidence to learn science.*

Finally, the additional category of *not easily identifiable* included GDEP participants who had changed their negative views of science from their secondary learning experiences towards positive views, often due to life experiences throughout secondary, tertiary and postgraduate education. It is noteworthy that the participants' pre and post-test scores often represented the median of the aggregate data, and it could be surmised these participants' combination of both positive and negative science learning experiences might be the reason for less extreme values on their PSTE and STOE. This group exemplifies the notion that self-efficacy is pliable and able to change due to contextualisation (Bandura, 2012; Bergman & Morphew, 2015).

Similar to Bleicher (2009), who posited the importance for designers of teacher training courses to be aware of the type of science learners, it is imperative for designers of postgraduate primary education courses to also be aware of types of learner within a subject as this is an integral factor of how the student will form their self-efficacy to teach the subject. Postgraduate students' life experiences may change their views on a subject and should be recognised and catered for, just as catering for those on either end of the spectrum of learner types.

Throughout the research many GDEP participants who were classed as *not clearly identifiable* tended to be students who had life experience beyond their undergraduate degree. These life experiences would further shape their self-efficacies and therefore investigation into the reasons that may affect the changes in attitude towards science would be beneficial, allowing for tertiary educators to appropriately plan units for this cohort of students.

While types of learners could be coded from the data, not all participants completed survey information for these items, and therefore, these questions should be reworded to encourage completion. As a limitation and similar to Bleicher (2009), it could be construed that some participants may have missed an opportunity to express their success as a science learner, or not used language to express their enthusiasm for science, and therefore may have been misplaced in one of the two categories. This may highlight the need for the development of an instrument that elicits specific data related to a type of science learner rather than general statements of prior science learning experiences. This instrument may further allow for deeper investigation into the reasons for the development of science learner types and consequences thereof.

It is recommended that further investigation into the types of learners across various curriculum areas within the primary school education sector is conducted; for example, this would allow for the identification of participants who may be a *fearful* learner across a number of learning areas including mathematics or physical education. There needs to be a deeper understanding what *disinterested* and *fearful* learners require in their preservice teacher training to improve their self-efficacy.

Conclusion

As this paper highlighted, there is a significant relationship between the type of science learner and the constructs (PSTE and STOE) of their primary science teaching self-efficacy. It demonstrated clear trends that *enthusiastic/successful* groups have higher efficacy compared to the *disinterested/fearful* groups, which is consistent with Bleicher's (2009) undergraduate cohort, but uniquely identified the *NCI* group situated between in the middle of this postgraduate cohort. The trends also showed that polar opposites occurred, whereby a potential ceiling effect in the PSTE of the *enthusiastic* groups led to a lower change in their PSTE, whereas the *fearful* group benefitted greatly from the intervention in increasing their confidence to teach primary science and demonstrated the largest significant increase in PSTE. Therefore, it is imperative that teacher education courses work to develop courses that help to build self-efficacy for these learners but also for those that are in the *NCI* and *disinterested* groups. This will mitigate the risk of *fearful* and *disinterested* learners choosing not to teach or give limited instructional time to areas where they have low efficacy or lack of interest, and instead show it is possible to learn and teach a subject that they are uncomfortable in. The increased self-efficacy of *NCI* learners may sway their ambivalence towards a more positive attitude and confidence to science with a consequence of increasing time spent to effectively teach primary science.

Increasing GDEP students' preparedness to meeting national teaching standards (AITSL, 2017) in teaching primary science needs to be facilitated through addressing science subject content and appropriate pedagogies in a manner that increases their self-efficacy whilst being sensitive to the type of learners they are. Meeting these standards has implications for the effective learning of subject content by students, in the hope of improving the standard of science education in Australia. This may see a strategic shift in philosophical decisions towards further enhancing specialist subject and pedagogical content knowledge in the generalist teacher or developing specialist staff supported by professional learning in engaging contemporary research informed PCK.

Data availability statement

The data that support the findings of this study are available from the corresponding author, CN, upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the authors.

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