Emotional Literacy and Pedagogical Confidence in Pre-Service Science and Mathematics Teachers

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Abstract: This report details the findings from initial research seeking to improve the pedagogical confidence of pre-service STEM teachers by encouraging emotional literacy in the form of affect awareness. The report discusses how affect was measured for the study, what the affect outcomes were and how these measures are conceptually related to improving confidence for the pre-service teachers (PSTs). Findings indicate enhanced emotional feedback enabled the PSTs to analyse, understand and make use of affect information to reflect on their teaching confidence overall. Ongoing research will need to address the issue of negative affect awareness in teacher training, and strategies for approaching this issue are provided.

Key words: STEM, pre-service teachers (PSTs), emotional literacy, affect, critical moments, emotional intelligence

Introduction

There has been a steady reduction in the number of students who are studying mathematics and science at both the secondary and tertiary levels of education in most advanced economies, and notably so in Australia (Ainley, Kos, & Nicholas, 2008; Lyons & Quinn, 2010). There is also a shortage of appropriately qualified mathematics and science teachers in schools (Harris & Farrell, 2007), especially at the secondary school level (Tytler, 2007). From this perspective the present imperative for teacher training in Australia (Australian Institute of Teaching and School Leadership, 2012) highlights teacher quality in the form of specific teaching standards (the Australian Professional Standards for Teachers), which seek to articulate quality teaching practices as the basis for improved student learning outcomes (cf. Hattie, 2003; Woolcott & Yeigh, 2015). Within this larger framework, the current research concerning emotional literacy and pedagogical confidence is viewed as both timely and applicable with respect to the development of quality teaching practices that are directed at the enhancement of teacher training in the areas of science and mathematics.

The findings in this report are from pilot research associated with a Science Technology, Engineering and Mathematics (STEM) program, *It's part of my life: Engaging*

university and community to enhance science and mathematics education (the Project), which seeks to address a lack of confidence and competence in science and mathematics instruction among teachers in primary (elementary school) and secondary (high school) Australian schools. The Project investigators addressed these issues through the development of interventions for pre-service teachers (PSTs) that focused on how mathematicians and scientists think and solve problems, and how this may be linked to the ways that people solve problems in everyday life. The PSTs were assessed on changes to their confidence in terms of how they applied this mathematical and scientific thinking to the planning, delivery, and reflection on their classroom lessons.

One important element of the reflective process concerned how the PSTs understood and utilised their emotional experiences, defined here as *affect*, in relation to pedagogy. Research suggests that affect, as a measure of emotional experience and understanding, is fundamental to the professional development of confidence and competence in teacher training (Tobin & Ritchie, 2012; Gahan & Lawrie, 2011; Kidman, 2012; Schweingruber, Keller & Quinn, 2012). The use of affect feedback was therefore viewed as widely relevant to the area of teacher training, as it may represent an important approach to improving pedagogical confidence during PST education. An important goal for the current study was therefore to develop greater PST awareness of their affective experiences and how this influenced their sense of pedagogical confidence. From this perspective the current report focuses on the development and application of affect measures used to provide feedback in relation to the PSTs' pedagogical self-reflections on their lesson preparation and subsequent lesson delivery in authentic classroom settings.

The proposed approach also arms the PSTs with affective-reflective skills, represented here by the term *emotional literacy*, which they can take with them into the workplace. With this in mind we present a brief framework to contextualise the study, followed by a description of the affect-related measures, our findings from the initial research trial and a discussion of these findings, including implications for future research.

Context for the Study

It is evident that engagement in the areas of science and mathematics learning is declining across most advanced economies (American Psychological Association, 2012; Olson & Riordan, 2012; The Royal Society, 2014). This is no less the case in Australia, and it appears that this decline in learning is associated with falling levels of confidence in teaching in these STEM related areas (Lyons & Quinn, 2015). For example, Thomson (2009) used the 2007 Trends in International Mathematics and Science Study (TIMSS) data[1] to identify a wide diversity of pedagogical confidence in Year 4 (4th Grade) Australian science and mathematics teachers, with teachers rating their preparedness to teach in science or mathematics anywhere from 37% to 88%, depending on topic area. Similarly, Australia's Chief Scientist and his colleagues have repeatedly expressed concern in relation to the state of Australian STEM education (OCS, 2012), a view supported by a report on quantitative skills from the Australian Association of Mathematics Teachers (2014). The Office of the Chief Scientist (OCS, 2014) has proposed that one key step in developing mathematics literacy in schools was by

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[1] TIMMS is a program that compares international assessments in mathematics and science, in order to improve teaching and learning in these areas globally. TIMMS is conducted by the International Association for the Evaluation of Educational Achievement (http://timssandpirls.bc.edu/).

> *"helping schools to teach STEM as it is practiced, in ways that engage students, encourage curiosity and reflection, and link classroom topics to the 'real world'"* (p. 23)

Thus, the decline in science and mathematics learning seems to be connected to the preparation of teachers in these same areas, and therefore requires intervention at the level of teacher training.

Nature of the Investigation and Theoretical Framework

Research by Tobin and Ritchie (2012) suggests that *emotional arousal* (positive or negative) is related to teaching confidence in PSTs. Similarly, studies by Jennings and Greenberg (2009), Kazemi and Hubbard (2008), Lave and Wenger (1991), and Rogoff (2003) support the notion that to fully understand learning of any sort we must include affective measures, which help to identify those cognitive-emotional aspects of learning that impact on interest, persistence in the face of difficulty, the ability to actively listen to others, and being able to respond to feedback in a critical and constructive manner.

In line with the findings of Tobin and Ritchie (2012), the current study seeks to address teacher preparation in the areas of science and mathematics by clarifying links between emotional awareness and pedagogical confidence, as related to contextualised learning in classrooms. To this end a highly collaborative and iterative approach was used to increase confidence for the PSTs involved in the study, by adopting a situated learning perspective, wherein PSTs worked in groups to develop pedagogical contexts and scenarios, guided by expert scientists, mathematicians, and pedagogy mentors. The PSTs worked collaboratively with these experts and mentors, to construct and optimize inter-dependent, scenario-based lessons that utilised local community contexts to increase the meaning of the lessons at the local school level. These lessons were then authentically delivered in local schools while being observed and recorded, and later analysed to provide feedback and reflection aimed at enhancing emotional literacy for the PSTs. Figure 1 provides a graphic depiction of this investigative approach.
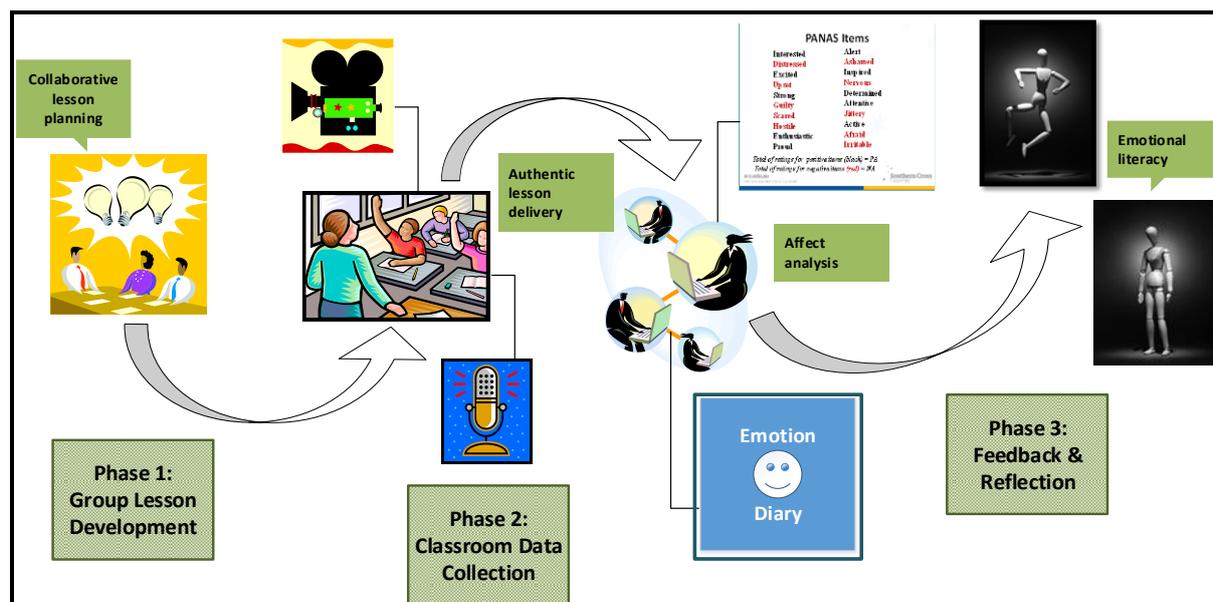

Figure 1: Graphic overview of the investigative approach

The notion of emotional literacy, as used here, seems to align with Goleman's (1995, 1998) theory of *emotional intelligence* (EQ), wherein EQ is defined as the ability to identify, assess and control one's own emotions, as well as respond appropriately to the emotions of others. In this respect, Goleman identifies five areas of emotional awareness that drive and motivate behavioural performance, including:

- self-awareness (knowing one's own emotional state and how this might be affecting others);
- self-regulation (managing one's own emotions in relation to the environment);
- social skill (managing the emotions of others, in order to direct them);
- empathy (recognising the feelings of others, in order to connect with them); and,
- motivation (being able to use EQ to achieve important goals).

The self-awareness construct suggested by Goleman appears to overlap with how PSTs in the current study were asked to reflect on their affect as they viewed their teaching videos. It is also important to note that the concept of emotional literacy, as conceived for the current study, also involves PSTs self-regulating their emotions in relation to the classroom environment, as well as their use of empathy and social skill to connect with school students and direct classroom learning. The purpose of emotional literacy in the current study is also to empower the PSTs to become more motivated to achieve greater pedagogical confidence, and thus this notion seems to encompass much the same elements of emotional understanding and activity that the larger theory of emotional intelligence represents. The current project also created an opportunity for peers to interact regarding their emotional experiences and possibly learn from observing others.

Methods

A mixed-methods approach was taken to the study, wherein the participating PSTs took part in collaborative discussion groups, completed self-report diaries, responded to an affect scale, contributed to self and peer analysis of audio/visual recordings of their classroom teaching and participated in self-and-peer-reflection sessions concerning their teaching and the enhancements they received from the expert scientists, mathematicians and pedagogy specialists. Post-lesson reflective questions were also used to examine how the PSTs used the emotional knowledge to inform their ongoing pedagogical decisions. The instruments used to collect affect information across these different procedures are organised in terms of data collection method and data type in Table 1. They are also detailed in terms of content and specific instructions in section 3.3 of this report. The current report focuses on the data provided by the Teaching PST with the PANAS and Emotion Diary and by the Observing PSTs using the same Emotion Diary to describe their peer's affect.

Participants

Participants in the pilot study phase of this research included seventeen PSTs who were training in the area of science and/or mathematics teaching. Ages for these PSTs ranged from 21-44 years, with an average age of 29.8 years. Each PST served as a Teaching PST for some lessons and then as an Observer PST while their peer taught. All PST participants were assigned to an 'enhancement' group where they worked with one another, a university pedagogy specialist, and a recognized science or mathematics expert to collaboratively develop lesson plans aimed at developing engaging lessons that also reflected the local

environment and context of the school where the lesson was to be delivered. Expertise was determined by the level of research impact and publication output for each 'expert', with the requirement that they must be part of a team recognised globally as level 4 or 5 in terms of research standards[2].

Once ethics approval and signed consent forms had been obtained from all relevant authorities (university participants, school system, parents and school students) the investigation was begun, following the process shown in Figure 1.

Procedures

Multiple sources of feedback were embedded across the investigation to ensure that the PSTs were able to reflect on their activities from different perspectives, and to include a range of feedback types. In terms of tracking the influences associated with the PSTs' confidence, various sources of feedback were provided to encourage PSTs to analyse and reflect on their learning and teaching in a way that connected what they were teaching, and what their school students were learning, to the contextualised content of the lessons (cf. Rothman et al., 2012). Table 1 provides an overview of these feedback sources.

Data Collection Method	Data Collection Type		
	Confidence	*Affect*	*Audio/Visual*
Self-Report	Pre & Post- lesson Confidence Checklists	Pre & Post-lesson PANAS* (Self-affect report)	Emotion Diary (Self-analysis of affect, critical moment recording from the recorded lesson – during reflection session)
Observer Report	In situ Confidence Checklist (completed by university educator)	Critical Moment Analysis	Emotion Diary (Peer-analysis of affect, critical moment recording from the recorded lesson – during reflection session)

(*Positive and Negative Affect Scale)
Table 1: Overview of feedback sources for pre-service teachers in the Project

It is important to note that the different types of feedback were incorporated into a series of iterated enhancement and feedback/reflection modules during the study. This ensured that the PSTs received important feedback from a variety of sources across the planning, delivery, analysis and reflection phases of the research.

Affect Measures

There were several different types of information and data that were recorded and analysed across the study, but this report focuses on the analysis of affect data and how this was used to promote emotional literacy as one element of pedagogical confidence for the PSTs. In this respect emotional arousal was operationally defined as affect for the study because affect represents the external expression of emotion as attached to ideas or mental representations. The affect measures were concerned with how the PSTs were analysing and interpreting their emotion-based behaviours in relation to their pedagogical thinking. In turn, the researchers were interested in what impact this might be having on the PSTs' sense of

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[2] These ratings refer to the Excellence in Research Australia (ERA) ratings, reported on a 1 to 5 scale, with ERA 5 being 'well above world standard' and ERA 4 being 'above world standard': www.arc.gov.au/era-2015

confidence about their teaching. From this perspective the research sought to measure the degree to which affect, and the corresponding ability to identify and regulate emotions, influenced pedagogical confidence in the PSTs.

As shown in Table 1, affect was measured using several different strategies, including a self-report measure of positive and negative affect (the PANAS), in-situ and post hoc observations of inferred emotion to identify 'critical moments' (places where affect was seen to affect pedagogy), and completing emotion diaries in relation to classroom teaching sessions (using indices of physical change - e.g., facial expressions, breathing rate, sweating, vasodilation [blushing], posture, tone of voice, etc.). It is important to note that the overall goal for measuring affect was to have the pre-service teachers learn how to identify the teaching-related affective states in themselves and one another in order to analyse the emotions and affective motivations that might be occurring, and to ensure they could assess the relationship between affect and confidence. A discussion of these individual measures follows.

The PANAS

The *Positive and Negative Affect Scale* (the PANAS, cf. Watson & Clark, 1999; Watson, Clark & Tellegen, 1988) was used to assess the different feelings PSTs experienced in relation to their teaching (see Figure 2).

Please read each item and then mark the appropriate answer in the space next to each word. Indicate to what extent you feel these things RIGHT NOW, that is, at the present moment. Please use the following scale to record your answers.

1	**2**	**3**	**4**	**5**
Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**

PANAS Items	
Interested	Alert
Distressed	Ashamed
Excited	Inspired
Upset	Nervous
Strong	Determined
Guilty	Attentive
Scared	Jittery
Hostile	Active
Enthusiastic	Afraid
Proud	Irritable
Total ratings for positive items (**black**) = **PA**	
Total ratings for negative items (**red**) = **NA**	

Figure 2: PANAS items used to measure PST affect

The PANAS is a valid and reliable measure of affect (Cronbach's α = .89 for the PA items and .85 for the NA items, with confirmatory factor analysis demonstrating independence between the two item sets - cf. Crawford & Henry, 2004). It is also fast and easy to complete, and for Trial 1 of the Project, PSTs self-completed this measure just before, and again just after, each contextualised lesson was delivered. The PANAS uses a 5-point scale to indicate the extent to which the PSTs were experiencing each of the PANAS emotion words at the moment of testing. The PSTs were instructed to complete this measure according to the instructions in Figure 2.

In terms of analysis, the ratings for the Positive Affect (PA) and Negative Affect (NA) items were summed to generate subscale scores. In addition, the per cent difference between PA and NA was computed using the following formula to denote the relative balance of positive and negative emotions within an individual while controlling for their overall endorsement of emotions: (PA-NA/PA+NA)*100. This PANAS information was integrated with other forms of emotion data to help inform an overall interpretation of the PSTs' emotions in relation to their teaching and learning.

Critical Moments

All teaching lessons from the enhancement and feedback iterations included full audio/visual (video) and separate audio recordings, which the PSTs used to analyse and reflect on their teaching. They were instructed to identify six 'critical teaching moments' for each lesson, where each 'critical moment' represented an important emotional experience associated with the pedagogical process of instruction, and which they felt influenced their confidence in relation to the lesson. Instructions for providing this aspect of the affect data were for PSTs to record the start and finish times for six segments of the video identified as representing a 'critical moment' for each lesson, seeking to identify two segments from the first third of the lesson, two segments from the middle third of the lesson, and two from the final third of the lesson. Segments were all less than two minutes in duration.

Emotion Diary

An Emotion Diary (Ritchie et al., 2014) was used to provide the data collection template for the critical moment segments identified in the audio/visual recordings of these lessons. The Emotion Diary is a one-page sheet that uses well-established affect icons and words representing their meaning to represent the various emotional states PSTs might experience during teaching (or observe in another PST's teaching). The diary was completed by selecting appropriate affect icons to represent the Teaching PST's emotions during teaching, and then selecting from the 1-5 scale a number that represented the intensity of the emotion next to the icon. The emotional states illustrated are *Excitement/Enthusiasm*, *Happiness*, *Enjoyment*, *Pride,* A*nxiety/Worry, Frustration, Disgust/Contempt, Annoyed/Irritated, Disappointed, Embarrassment, Interested*, *Confident*.

The emotion diary also provided space for writing open-ended comments about the selected emotions, and PSTs were encouraged to use this space to elaborate and explain their affective identifications in terms of what the teaching PST was doing at the time, what else might be going on in the classroom, and at whom the emotion seemed to be directed. Emotion Diary ratings were also recorded by Observer PSTs for the same critical moments identified by the Teaching PST, allowing comparisons to be made between experienced and observed affect for each PST. These comparisons assisted in identifying affect-related issues for the PSTs, as well as highlighting affective trends in the overall iterations that took place across the study trials.

To complete these diaries, PSTs were trained to recognise emotions in terms of observing changes in voice volume, pitch, tone or other sound qualities when observing one another, and when analysing their own video recordings. They were also trained to notice how overall body language during teaching (e.g., facial expressions, breathing rate, sweating, vasodilation [blushing], posture, increased muscle tension, etc.) might indicate a particular

feeling or bodily sensation. All PSTs were instructed to use this training to direct their diary recordings.

Teaching and Observing PSTs were instructed to complete an Emotion Diary for each critical moment segment identified in the audio/visual recording of the Teaching PST's lesson delivery. This allowed the study to compare and contrast multiple 'experienced' and 'observed' affective states, and therefore provided some level of reliability for the diary strategy. These Emotion Diary records were utilized by the teaching PSTs to reflect on their lesson deliveries via the audio/visual recordings. All PSTs used the same diary template, but the orientation of the diary varied according to whether it directed emotional analysis from the perspective of the Teaching PST or an Observer PST. Note that this Emotion Diary also directs the Teaching PST to focus on what they were doing, what was happening in the classroom, and at whom the emotion they experienced was directed (e.g., at her or himself, a student or group of students, the supervising teacher, etc.). The PSTs were encouraged to use the space provided on the diary to elaborate and explain their affective identifications in terms of what they were experiencing and how they felt this was influencing their interactions with others.

Findings

The findings of this study support the use of affect data to examine emotional literacy in PSTs. Indeed, the efficacy of this type of analysis appears to broadly support having PSTs identify and analyse their teaching-related affective states in order to assess their own emotions and motivations. It is therefore felt that, irrespective of the pilot nature of the study, it is important to report on the current findings promptly, in order to ensure that the relationship between emotional literacy and effective pedagogy is disseminated for further research and review within the teacher-training community.

PANAS Data

The overall PANAS data for this initial study is displayed in Figure 3. As noted previously, a differential scale was constructed from the overall positive and negative PANAS ratings to indicate when PSTs were affectively more positive and when they were more negative. This Figure displays the positive and negative Teaching PSTs PANAS ratings as measured just prior to lesson delivery and again just after lesson delivery. Note that PANAS differential (PDIF) is an index of the percentage difference between PA and NA, while accounting for the overall level of reporting for each individual. Higher values post lesson represent a greater PA relative to NA due to an increase in PA or a decrease in NA.

The findings indicate little change in PA over time but a significant decrease in NA (2-tailed, paired samples $t_{[24]} = 5.34$ p<.001) and a significant increase in PDIF (2-tailed paired samples $t_{[24]} = -3.57$, p< .01). The increase in the relative values of PA and NA is, therefore, driven by a drop in NA, and not an increase in PA.
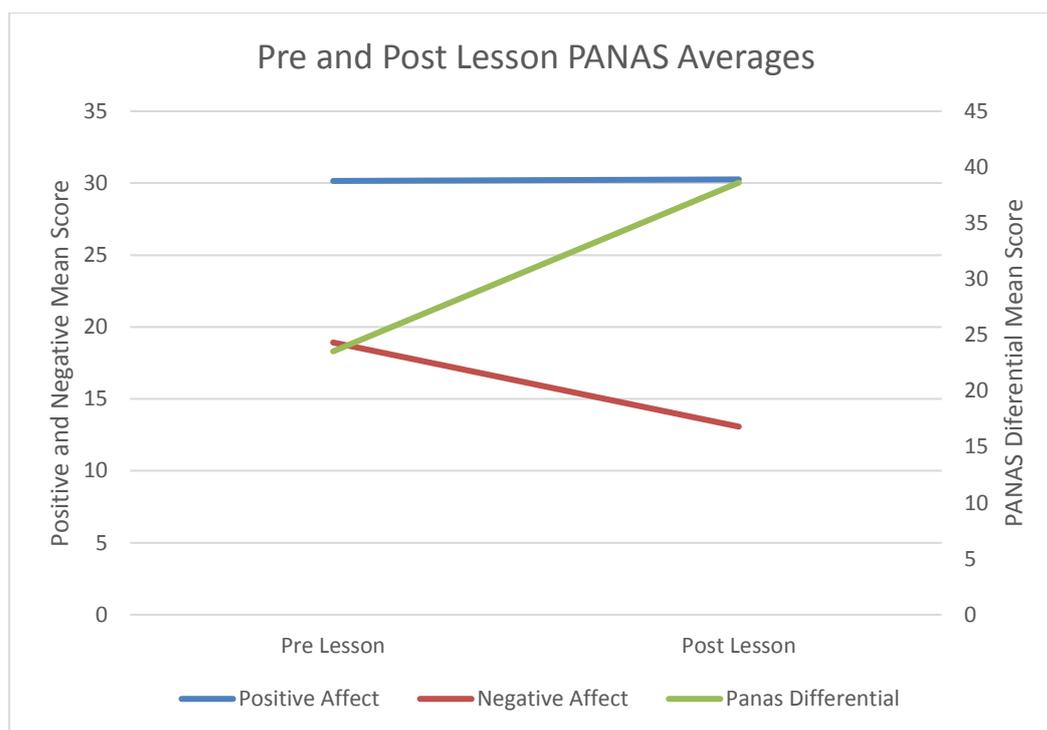
Figure 3: Overview of pre- & post-lesson PANAS scores of the Teaching PST. The Positive Affect (PA) and the Negative Affect (NA) are graphed relative to the left axis and PANAS Differential (PDIF) scores are graphed relative to the right axis. PA = Averaged sum of ratings of positive affective terms across Teaching PSTs, NA = Averaged sum of ratings of negative affective terms across Teaching PSTs, and PDIF = Per cent difference in PA versus NA while controlling for overall reporting of affect ((PA-NA)/(PA + NA)*100). Positive PDIF scores represent PA being greater than NA, while negative PDIF scores indicate PA being lower than NA.

Critical Moment Analysis

Critical moment analysis involved both the Teaching and Observer PSTs using the emotion diaries to analyse and reflect on the affective states of the Teaching PTSs during selected segments of lesson delivery. The Teaching PSTs identified and analysed their own critical moments from the audio/visual recording for that lesson, representing important points at which some form of affect had influenced their pedagogy. Observer PSTs also analysed the audio/visual recording according to the identified time signature for each critical moment (as provided by the Teaching PST), and provided feedback on the affect they observed in relation to each identified moment.

A comparative overview of the mean differences between reported emotion versus observed emotion is presented in Figure 4. There were three significant differences in relation to these critical moment analyses, involving differences between reported and observed *Anxiety/Worry* ($t_{[17]}= 2.62$, $p<.02$), between reported and observed *Confident* ($t_{[17]}= -2.20$, $p<.05$), and between reported and observed *Embarrassment* ($t_{[17]}= 2.21$, $p<.05$). It should also be noted that on average the Observer PSTs tended to report higher levels of positive emotion and lower levels of negative emotion than did the Teaching PSTs for each lesson.
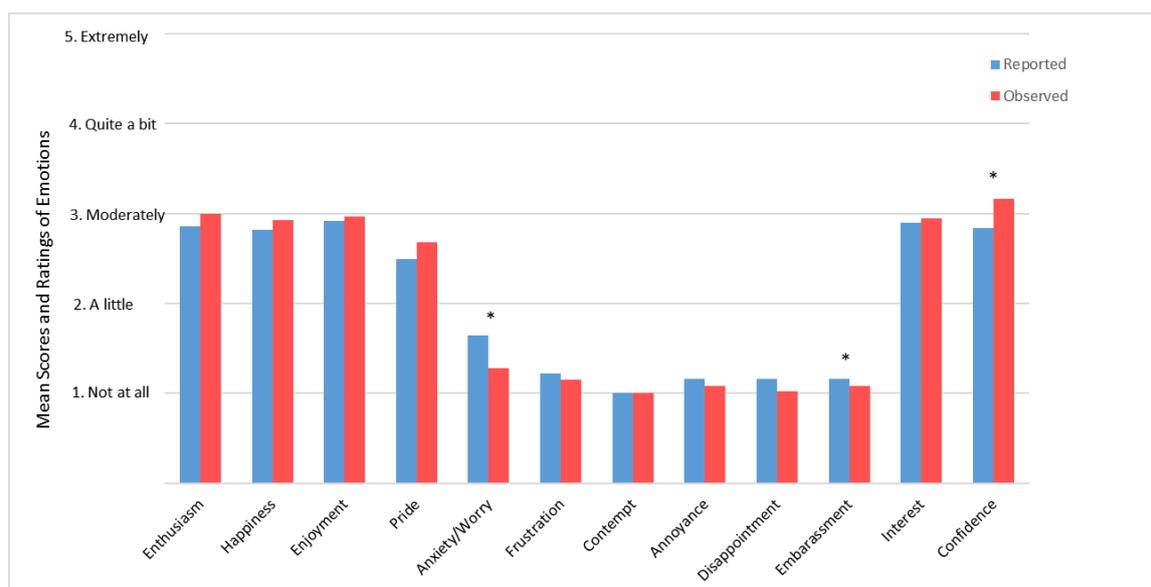
Figure 4: **Average Emotion Diary ratings for critical moment data by PST group type (Teaching vs Observing). * = significant group differences at p < .05.**

Discussion

There are several interesting outcomes from these findings that relate to the methods and goals of this research and which also appear broadly relevant to teacher training. Firstly, with respect to the PANAS data, it is clear that PSTs tended to experience greater positive than negative affect in relation to their teaching overall. As shown in Figure 3, however, whereas there was almost no pre- and post-lesson affect 'movement' in relation to the positive PANAS ratings, there was considerable negative movement in relation to the negative ratings, with lower post-lesson negative affect clearly evident. This finding was unexpected. Lower negative affect after having delivered a lesson is logically intuitive, in that we would expect the PSTs to feel a type of 'emotional relief' from worry or self-doubt once they had finished each lesson. However the obverse to this is also intuitive and therefore we would also expect them to experience a corresponding 'burst' of positive emotion upon completing a lesson, yet this was not the case. This imbalance is reinforced when we look at the PANAS differential findings, which show a more exaggerated positive swing for the post-lesson data overall. This suggests that the extent of differences between individual positive and negative scores were greater than suggested in the pre-and-post ratings themselves, with the differential scoring process identifying this as an overall positive bias on the part of the PSTs, yet due to a greater fall in negative affect, overall.

Looking more closely at the emotion scoring in relation to the critical teaching moments, it seems that these discrepancies are linked to quite specific emotion item differentials, where we find that significant differences occurred between reported and observed *Anxiety/Worry* for the PSTs, between reported and observed confidence (*Confident* in the diary), and between reported and observed *Embarrassment*. The relationship between observed and reported confidence ratings is of particular interest here, as this finding suggests that the confidence PSTs were experiencing and the confidence they were displaying was rated differently based on Teaching and Observer PST perspectives. These outcomes support the underlying goal of the research, to increase pedagogical confidence via emotional literacy, as being an aspect of teacher training worthy of pursuit. They also suggest that overall PANAS findings may be masking individual differences when it comes to the display

of specific negative emotions, and the impact this may have on perceived confidence. The contrast between ratings from those teaching and those observing would also be important content for reflection sessions.

In particular, the use of critical teaching moment analysis revealed that the observer PSTs tended to note higher levels of positive emotion, and lower levels of negative emotion, than did the observed PSTs. This was especially true for *Excitement/Enthusiasm*, *Happiness*, *Enjoyment*, *Pride* and *Interested*, which all represent positive forms of affect. Note also, however, that the Teaching PSTs self-reported much greater *Anxiety/Worry* than reported by the Observer PSTs. As with all self-report and observer measures, these findings need to be first considered in terms of reporting styles under the current circumstances. These preliminary results may be due to reporting tendencies where those being assessed tend to under-or-over-report certain aspects of their emotional experience and level of confidence, while those peers who were reporting on their fellow student's emotional displays may have tended to report more positively out of kindness.

Of importance to this report is that, when taken together, these findings seem to highlight an issue with respect to affect regulation, and thus raise certain questions concerning to what degree the PSTs might be consciously or unconsciously controlling particular emotions during teaching. Perhaps a form of emotional control is taking place for the PSTs during their teaching, but if so, is this a conscious strategy, or is it occurring outside of their awareness? Is the assessment of the capacity to sense one's emotional variations and consciously apply a regulation strategy something that should be included in teacher training? These questions are important because they represent precisely those cognitive-emotional aspects of learning that the research is aiming to uncover, and which are necessary for informing future research in the area. For example, control strategies and the meanings ascribed to the experience by PSTs could be seen as adaptive or as a preoccupation that interferes with effective teaching. Considering emotion regulation strategies during lesson planning, lesson delivery, affective assessment and reflection may be an important focus for future research as we consider how to best use these methods in relation to teacher training. The use of qualitative data regarding the thoughts or beliefs attached to the emotions PSTs identify may also inform the direction of this training.

In this respect it is important to note that in the reflective discussions about affect analysis, PSTs affirmed a view that it was important to display teaching confidence when delivering a lesson, but also reported that they had not been generally aware of 'pushing down' their more negative or positive emotions during lessons, until such time as they were able to receive collaborative feedback from others and review the recorded lessons for critical moment analysis. Seeing the ratings from their peers and hearing the feedback about how positively they presented themselves appeared to contribute to greater collegiality but also an opportunity to look more compassionately at what went well and what required more attention. This highlights the importance of collaborative affect analysis as a means of achieving emotional literacy as understood by the current study. It also underscores the complexity of emotional learning when applied to authentic situations that involve professional development, reinforcing the need to further develop and refine emotional literacy as a valuable aspect of teacher training.

Ongoing Research

One of the clearest outcomes from this early analysis of the study's affect data is that there are individual differences in emotional display and the capacity to sense how their affective states are appearing to others. In this respect ongoing research will need to

investigate the degree to which PSTs are aware of their emotions *in situ*, and can use feedback and reflection to develop adaptive strategies that enhance their teaching. Factors such as why they attempt to control certain emotions in certain classroom situations or when delivering particular content in math or science would assist in linking affect to pedagogy. The use of a dedicated debriefing session aimed at exploring these specific aspects of the reflective process could be used to further train PSTs in this direction. Additionally, incorporating specific reflective prompts into the critical moment analysis strategy could also be used to elicit this sort of information. For example prompts might include, "Be sure to identify any discrepancies that may have occurred between the emotions you experienced during lesson delivery and the emotions others observed for you at that time"; "Why do you think this discrepancy occurred?"; "What were you thinking while you experienced this emotion?"; and, "What could you think when you sense this emotion that might lessen its impact on your confidence in the future?".

The use of prompts like these could be used to help improve PST emotional awareness for ongoing research in terms of connecting the experience of distinct emotions to individual behavioural responses, and in turn clarifying these with respect to the cognitive-emotional elements of the situation. This is of particular interest to ongoing research because it offers an expanded approach to emotional literacy, and thereby provides a more holistic basis for investigating cognitive-emotional learning as a distinct aspect of pedagogical confidence.

Study Limitations

The main limitation for this report is the pilot nature of the reported study, involving a small sample size that makes generalisation difficult. However, the emergence of some significant findings in spite of this limitation is reassuring, and suggests that larger samples engaged across various education settings might allow us to uncover more specific principles and relationships among affect analysis and pedagogical competence and confidence. Small sample size may well be a typical issue associated with the collection of authentic classroom data for research in the area of teacher-training, but the current authors do expect to overcome this limitation in our ongoing research as we trial different technologies, instruments and strategies for scaling-up the study and conducting further, ongoing analyses.

Conclusion

We note that affect typically refers to the external signs of internal emotion-related activity or experiences. The investigative process that was followed in the current study, during which PSTs reflected on reports from others and their own assessment of what they saw in the audio/visual recordings, gave rise to the analysis and interpretation of their perceived emotions and the impact this had on their teaching. One would hope that this process might exercise or enhance an 'emotional literacy' that could then be applied later, possibly during a following lesson. In this report we have focused on the initial analyses of how research associated with the Project used affective measures as part of the iterative processes by which PSTs explored and analysed the pedagogy connected to their teacher training. From the findings we can already see that the PSTs have exhibited a positive emotional bias overall, yet also displayed greater changes in their negative versus positive emotions. In addition, Observer PSTs tended to perceive less negative emotion, more positive

emotion and greater confidence in their peers than the Teaching PST who had delivered the lesson reported her or himself.

Overall, these findings indicate that the use of affect analysis in the context of expert-enhanced lesson planning is appropriate as one means of mitigating the lack of confidence in science and mathematics teachers as part of their pre-service training. The findings also provide clear avenues for improvement with respect to some aspects of the reflective process, suggesting the need to forge clearer conscious correspondences between affect and cognitive-emotional learning in PSTs and training teachers, especially in relation to the recognition of negative emotions and the cognitions that might accompany these. In this respect ongoing PST training will need to modify certain elements within the reflective process, and this is viewed as an important way forward for the relevant research. For the current study, the effect of these modifications will be to better connect emotional literacy to the study's outcomes, in order to improve the overall goal of developing quality teaching practices that are directed at the enhancement of science and mathematics teaching in Australian schools and beyond. Perhaps the true importance of these findings, however, is that affect analysis appears to contribute to teacher-training in measurable and effective ways, and that the pursuit of emotional literacy, as an instance of situated emotional intelligence, has the capacity to enhance pedagogical confidence at a very practical level. Surely this is good news for the future of STEM related learning in the classrooms of Australia and beyond.

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