Using Emotional Literacy to improve Pedagogical Confidence: Initial Findings from a STEM Project

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Abstract
This paper reports on the initial research findings from a multi-institutional STEM project (the Project: It's Part of MY Life) focused on improving the scientific and mathematical thinking of pre-service teachers (PSTs) by enhancing their pedagogical confidence via improved emotional literacy. This report details how the Project trials have utilised enhanced emotional feedback to enable PSTs to analyse, understand and make use of emotional information to improve their teaching confidence and teaching competence. The report discusses emotional literacy and emotional regulation as aspects of self-reflective professional development, how affect measures were constructed for the project, and how these measures are conceptually related to improving competence and confidence for pre-service STEM teachers. An overview of the research methods designed to connect emotional literacy to the Project goals is also provided, and recommendations made for ongoing research within the project parametres.

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

Introduction

This paper reports on the initial stages of an OLT STEM program, "The Project: It's Part of My Life" (the Project) that seeks to address a lack of confidence and competence in science and mathematics instruction for teachers in lower and middle regional and rural Australian schools. In line with the Australian Professional Standards for Teachers (Australian Institute of Teaching and School Leadership, 2012; cf. Hattie, 2003), the Project looks to improve confidence and competence in science and mathematics through the development of interventions that focus 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. This report focuses on the development and application of affect measures used by the Project to provide feedback in relation to Pre-Service Teachers' (PSTs) pedagogical self-reflections on their lesson preparation and lesson delivery.

Affect, as a measure of emotional experience and understanding, is viewed as fundamental to the professional development of confidence and competence in teacher training (Tobin & Ritchie, 2012), and the Project's use of affective feedback thus represents an important aspect of achieving the larger Project goals of improving these aspects of pre-service training. With this in mind a brief framework to contextualise and position the Project is presented, followed by a description of the affect-related measures and their findings from the initial Project trial. Improvements to the measures, in particular how to use these to better connect emotional literacy to appropriate research goals, are then recommended as a focus for ongoing research within the overall Project parametres.

Context and Theoretical Framework

There has been a steady reduction in the number of Australian students who are studying mathematics and science at both the secondary (high school) and tertiary levels of education (Ainsley, Kos, & Nicholas, 2008; Lyons & Quinn, 2010). There is also a shortage of appropriately qualified mathematics and science teachers available to teach at the secondary school level, particularly in rural schools (Harris & Farrell, 2007; Tytler, 2007). For example, Thomson (2009), in a report based on the 2007 TIMSS data, identified that many Year-4 (4^{th} Grade) teachers reported having little specific training or specialised education upon which to base their teaching of the TIMSS assessment topics. Similarly, Australia's Chief Scientist has repeatedly expressed his concern in relation to the state of Australian STEM education (Office of the Chief Scientist, 2012; 2014). He also identified that crucial influences on the style of STEM teaching included "time and resource constraints, and in some cases confidence and training" (2012, p. 10) and that "there is now a shortage of qualified science, mathematics and information communications technology teachers, and the participation rates of Australian school and tertiary students in STEM disciplines remain a matter of concern" (2014, p. 21). Importantly, he has also proposed that one key step in developing STEM literacy in schools was by "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'" (2014, p. 23).

The Project seeks to address such issues by clarifying links between content knowledge and confidence as related to contextualised or situated learning in

Australian classrooms (cf. Kidman, 2012). In trial 1 of the Project this was enacted by having pre-service teachers (PSTs) work in groups to develop pedagogical contexts and scenarios, guided by expert scientists and pedagogy mentors, to construct and optimize inter-dependent and collaborative scenario-based lessons that utilised local community contexts to increase the meaning of the lessons (Gahan & Lawrie, 2011).

Sources of Feedback to Encourage Competence and Confidence

In terms of tracking the influences associated with STEM teaching, 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. Figure 1 provides an overview of these feedback sources. It is important to note that these sources of feedback were incorporated into a series of iterated enhancement and feedback/reflection modules during trial 1 of the Project. Enhancement modules involved interactions between the PSTs and world-class science researchers, and between PSTs and experienced educators who specialise in the area of classroom pedagogy. The feedback modules involved collaborative groups of PSTs analysing their teaching and how they had made use of the expert advice, as well as including input and guidance from their pedagogical mentors. As the PSTs developed experience across the modules, they then began mentoring less-experienced colleagues, providing yet another source of feedback for the Project.

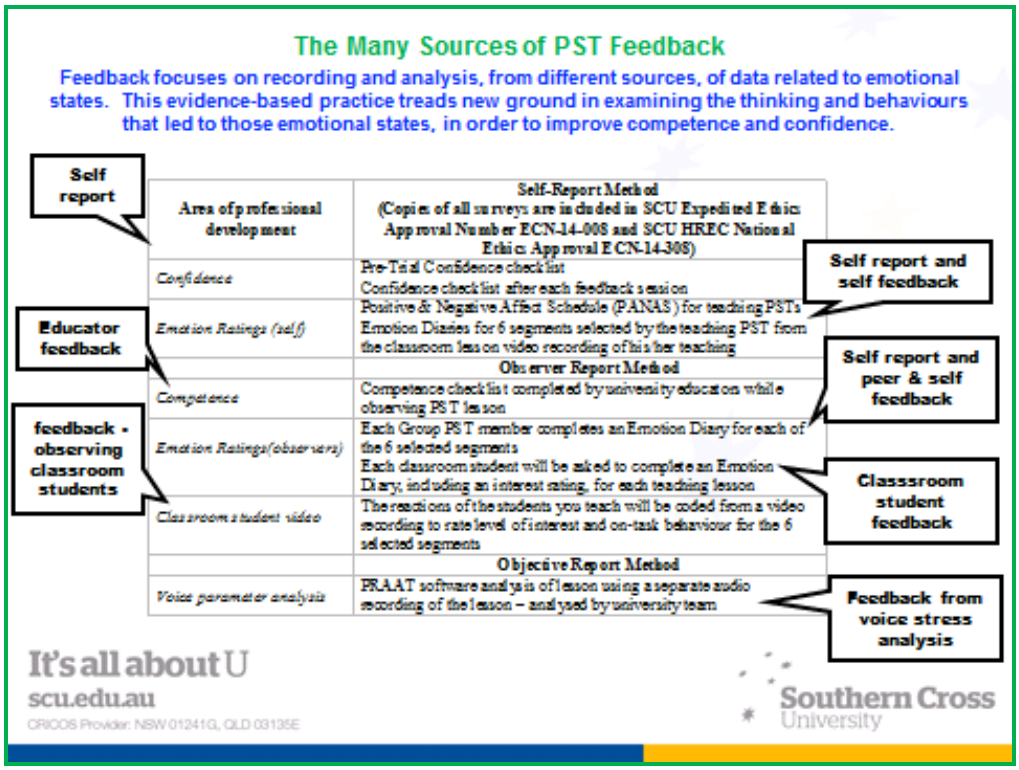

Figure 1: Overview of feedback sources for pre-service teachers in the Project (Slide from presentation given at the 2014 Asian Conference on Education, Osaka, Japan)

The Role of Affect in Teacher Confidence & Competence

As indicated in Figure 1, an important part of the reflective processes for the Project involved *affect* feedback, including the emotion ratings, the video recordings, and the voice parameter analysis. Research by Tobin and Ritchie (2012) suggests that *emotional arousal* (positive or negative) is related to teaching competence and confidence in PSTs, and because of this the particular focus of this report concerns how the Project utilised these sources of feedback to assess and analyse PST affect in relation to the scenario-based lessons they developed in conjunction with the expert scientists and pedagogy mentors (Rothman et al., 2012). Emotional arousal was operationally defined as affect for the Project because affect represents the external expression of emotion as attached to ideas or mental representations. Thus these measures were concerned with how the PSTs were analysing and interpreting their emotions in relation to their teaching, and what impact this was having on their confidence and sense of competence about the teaching. In this respect the Project sought to measure the degree to which affect, and the corresponding ability to regulate emotions, moderated confidence in the PSTs, and how this then influenced their competence.

Affect Measures

Affect was measured from a variety of perspectives and 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, 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.), and prosody analysis (using the PRAAT, a dedicated software program that analyses recorded voice prints to identify when stress occurred during the teaching sessions). PRAAT analysis has yet to be completed for Trial 1 of the Project, and thus cannot be reported on here. However initial data has been analysed for the other affect measures, and is reported on below. It is important to note that the overall goal for measuring affect was to have the pre-service teachers learn how to identify and analyse their teaching-related affective states in order to assess their own emotions and motivations, and to ensure that the emotional and motivational climate of the classroom was optimally supportive for the learning of their students (Tobin & Ritchie, 2012). Figure 2 provides an overview of the affect measures, as utilised in trial 1 of the Project. A discussion of individual measures follows.

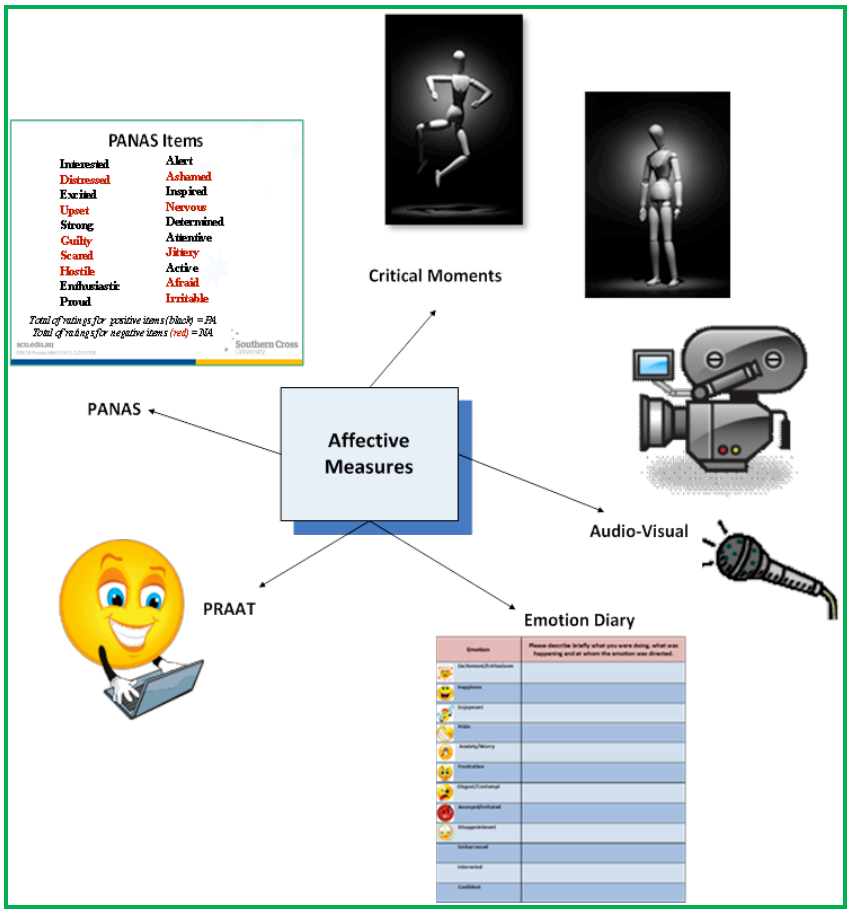

Figure 2: Overview of affect measures used in the Project

The PANAS

The *Positive and Negative Affect Scale* (the PANAS, see Watson, Clark & Tellegen, 1988) was used to assess the different feelings PSTs experienced in relation to their teaching. The PANAS is a valid and reliable measure of affect (Cronbach's $\alpha = .89$ 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 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 time of testing. The PSTs were instructed to complete this measure according to the following instructions:

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

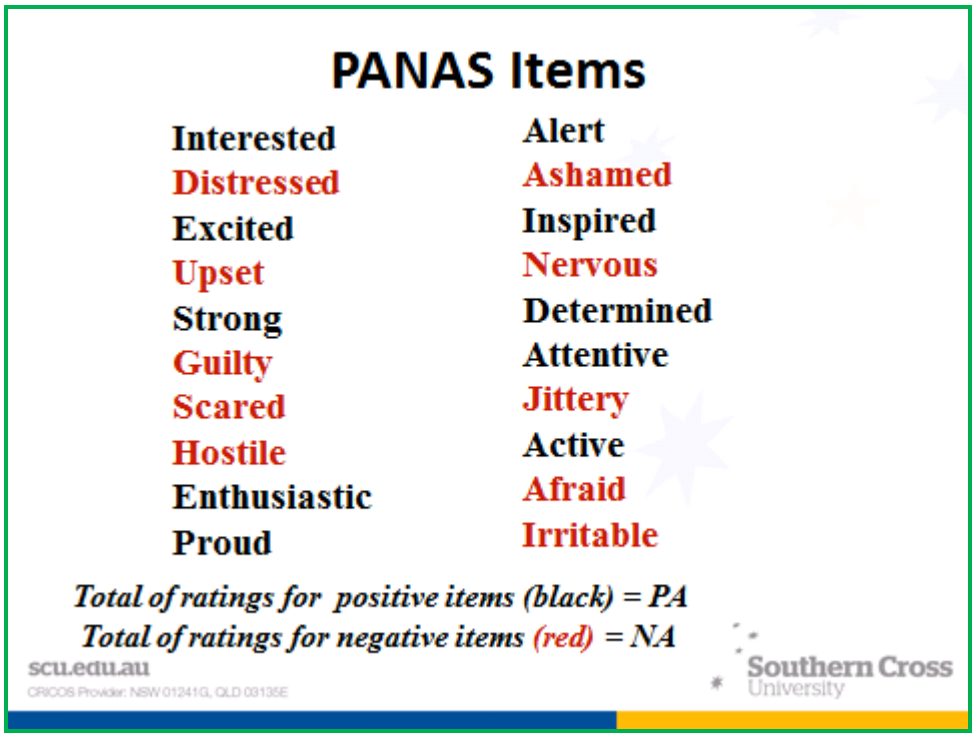

Figure 3: PANAS items used to measure PST affect

In terms of analysis, the Project used differences between the PANAS positive and negative item ratings to construct a differential scale, indicating when PSTs were affectively more positive and when they were more negative. This information was then compared 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, and PSTs then used the video recordings to analyse and reflect on their teaching. In particular, they identified six "critical teaching moments" for each lesson, where each "moment" represented an important emotional feeling or experience associated with the pedagogical process of instruction, that they felt influenced their competence and/or 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, and seeking to identify two segments from the first 1/3 of the lesson, two segments from the middle 1/3 of the lesson, and two from the final 1/3 of the lesson.

Critical moment data was also recorded in the same manner by observing PTSs, 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 during trial 1 of the Project.

Emotion Diary

PSTs were also asked to complete an emotion diary for the critical moment segments identified in relation to their teaching. The emotion diaries used well-established affect icons and their meanings to represent the various emotional states PSTs might experience during teaching (or observe in another PST's teaching), as shown in figure 4. 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.

Using this training to direct their diary recordings, observing PSTs were instructed to complete an emotion diary for each teaching PST during lesson delivery, and both observing and teaching PSTs were additionally instructed to complete an emotion diary for each "critical moment" segment identified in the video recording by the teaching PST. The diary was completed by selecting appropriate affect icons to represent the teaching PST's emotions during teaching, and then using the scale below to write a number that represented the intensity of the emotion next to the icon. As shown in figure 4, the emotion diary also provided space to write 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.

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

Emotion	Please describe briefly what you were doing, what was happening and at whom the emotion was directed.
 Excitement/Enthusiasm	
 Happiness	
 Enjoyment	
 Pride	
 Anxiety/Worry	
 Frustration	
 Disgust/Contempt	
 Annoyed/Irritated	
 Disappointment	
Embarrassed	
Interested	
Confident	

Figure 4: The emotion diary used to identify affect during teaching sessions and in relation to reflective lesson analysis

Project Survey Data

A survey (n = 130) designed to measure the target constructs of the Project was also completed by PSTs (Whannell, Woolcott & Whannell, 2014). Factor analysis, using a direct oblimin rotation based on a consideration that the survey factors would be correlated (Smith & Huinker, 2000), and the eigenvalue "greater than one rule" (Ho, 2006), in conjunction an examination of the associated Scree plot (Zwick & Velicer, 1982), indicated that four underlying factors were represented by the survey: a "Mathematical Thinking Scale", a "Student Support Teaching Scale", a "Mathematics Teaching Pedagogy Scale", and a "Teacher Reflection Scale".

This four-factor solution comprised a total of 28 items and accounted for 75.6% of the variance in the constituent items of the survey. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was .903, and Bartlett's Test of Sphericity ($p < .001$) indicated that the correlation matrix was suitable for factor analysis. Cronbach's alpha was used to determine the level of internal consistency for each of the scales identified, as shown in table 1. George and Mallery (2003) identify a Cronbach's alpha of .9 or

above as excellent and .8 or above as good, and thus all four scales are considered robust with respect to representing the Project constructs reliably.

Table 1: Reliability estimates for the Project survey scales

Scale	**Cronbach's Alpha**	**Inter-Item Correlations**
Mathematical Thinking Scale	.97	.532 to .845 ($p < .01$)
Student Support Teaching Scale	.89	.540 to .725 ($p < .01$)
Mathematics Teaching Pedagogy Scale	.92	.522 to .888 ($p < .01$)
Teacher Reflection Scale	.85	.571 to .715 ($p < .01$)

Of particular importance to this report is the "Teacher Reflection Scale" (TRS), which includes emotional analysis as part of the scale. This scale displays significant positive correlations (Spearman's Rho) to other important items in the survey, including mathematical thinking, being able to support school students, and pedagogical confidence. However, it also displays a non-significant but negative correlation to the number of mathematical curriculum units completed at university, suggesting that content knowledge by itself does not provide sufficient reflective insight for pre-service teachers. This supports the need to develop the reflective aspects of teacher training in disciplines like science and mathematics, and therefore also supports the Project's goal of using affective analysis to improve the competence and confidence of training teachers.

Affect Findings

The Project trial 1data is incomplete at this stage; however early findings do support the use of affective data to examine the thinking and behaviours that led to emotional states in pre-service teachers (PSTs). It is also felt that a need exists to report on the current findings promptly, as the purpose of these analyses is to assist PSTs improve their ongoing competence and confidence in STEM-related teaching, and these outcomes appear to support the efficacy of having PSTs learn how to identify and analyse their teaching-related affective states in order to assess their own emotions and motivations, and to ensure that they understand the relationship between emotional literacy and effective pedagogy. Thus the immediate dissemination of these findings is considered worthwhile at the present time.

PANAS Data

The overall PANAS data for trial 1 is displayed in figure 5. As noted prior, 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 PANAS ratings as measured just prior to lesson delivery and again just after lesson delivery, as well as the overall pre-and-post differentials relating to these measures.

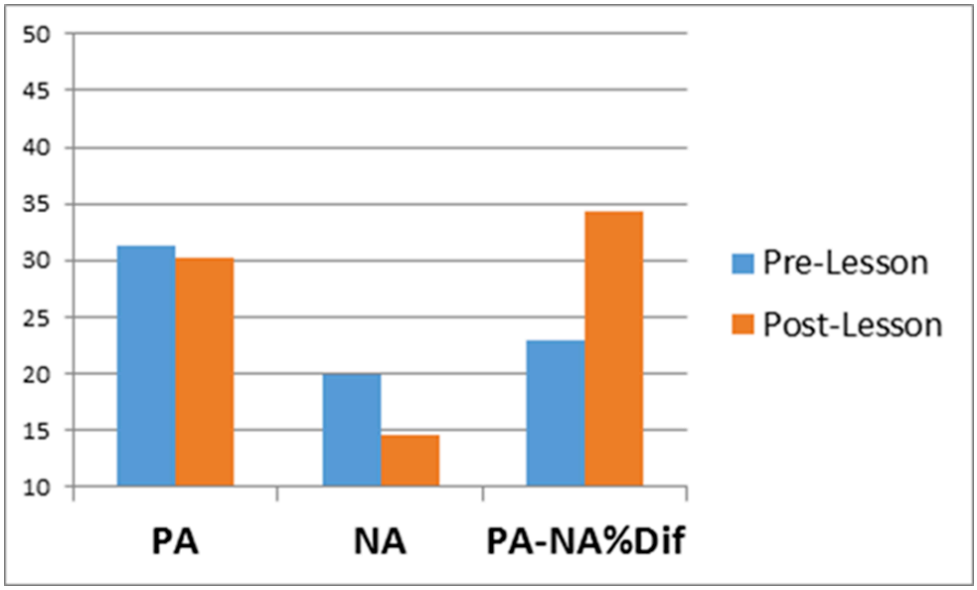

Figure 5: Overview of pre & post PANAS differences
(From Donnelly et al., 2014; used with permission)

Critical Moment Analysis

Critical moment analysis involved both the teaching and observing PSTs using the video recordings to analyse and reflect on the affective states of the teaching PTS's during lesson delivery. For each lesson, the teaching PST initially identified and analysed six critical moments from the video, representing important points at which some form of affect had influenced their pedagogy. The non-teaching PSTs then also analysed the video according to the identified time signature for each "moment", and provided feedback on the affect they observed in relation to each identified moment.

A mean comparative overview of how these critical moments were analysed in terms of reported affect versus observed affect - for PSTs who had received enhancement for the lessons they delivered and for PSTs who had not received enhancement for the lessons they delivered - is presented in figure 6. 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 *confidence* ($t_{[17]}$= -2.20, p<.05), and between reported and observed *embarrassment* ($t_{[17]}$= 2.21, p<.05). It should also to be noted that on average the "no enhancement" group tended to experience and report higher levels of positive emotion, and lower levels of negative emotion, than did the "enhancement" group.

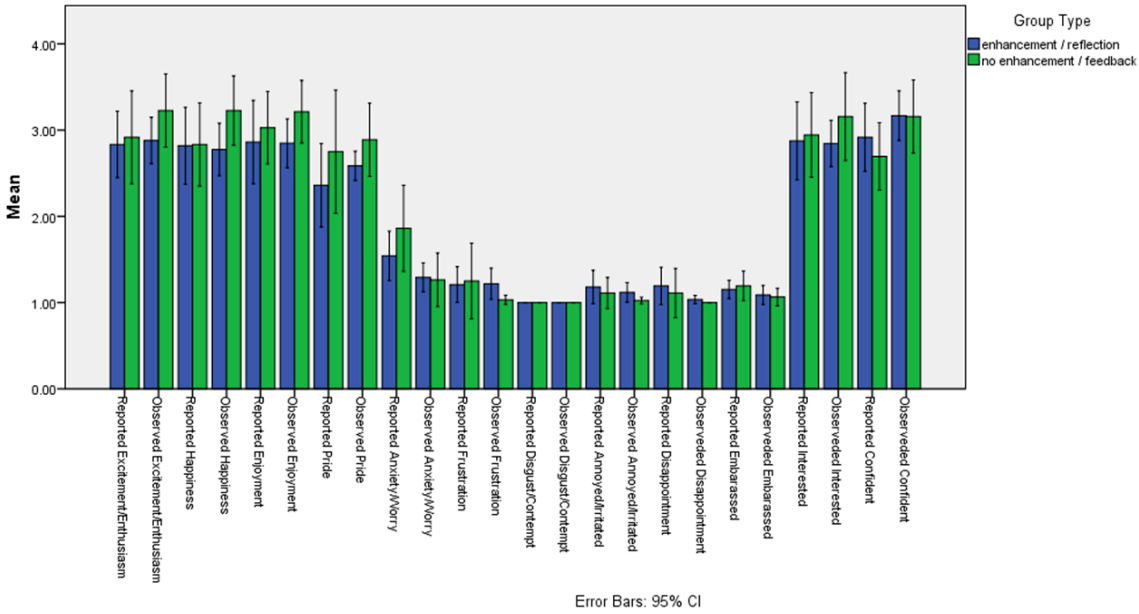

Figure 6: Critical moment data by group type
(Graph by Matthew Snow, Psychology, SCU; used with permission)

Teacher Reflection Scale

The Project survey covers far wider ground than just the affective domains of the Project, and thus its relevance to this particular report is limited. Nonetheless several findings from the factor analysis performed on the survey do appear relevant to the current report, including the existence of a Teacher Reflection Scale (TRS) as a valid Project construct, and that significant positive relationships exist between the TRS and mathematical thinking, being able to support school students, and pedagogical confidence. In addition, it is of particular interest that the correlation between the TRS and the number of mathematical curriculum units completed at university is negative. This suggests that the amount of experience that the respondents had in terms of formalised mathematical learning was inversely associated with their reflections on teaching practice or on the respondents' understanding of the impact of emotions on teaching. Considering that the identification of strategies to enhance PST confidence and competence through reflection is one of the primary aims of the Project, these overall findings indicate that opportunity exists for the Project to make a genuine contribution to the training of pre-service teachers in the STEM area.

Discussion

Although analysis of the Project trial 1data is incomplete at this stage, there are nonetheless several interesting outcomes that appear to relate to the Project methods and goals. 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 5 however, whereas there was almost no pre-and-post 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 is a bit 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" 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.

Looking more closely at the PANAS scoring in relation to the critical teaching moments, it seems that discrepancies are also linked to quite specific PANAS differences, where we found that significant differences occurred between reported and observed *anxiety/worry* for the PSTs ($t_{[17]}= 2.62$, $p<.02$), between reported and observed *confidence* ($t_{[17]}= -2.20$, $p<.05$), and between reported and observed *embarrassment* ($t_{[17]}= 2.21$, $p<.05$). The relationship between observed and reported confidence is of particular interest here, as this relationship was negative, and therefore this finding suggests that the confidence PSTs were experiencing and the confidence they were displaying were quite opposite to one another.

Of importance to the Project goals is that, as a composite, these findings may highlight an issue with respect to affect regulation, that is, they raise certain questions concerning to what degree the PSTs might be consciously or unconsciously controlling particular emotions during teaching. In this respect the question is whether or not this is a conscious strategy, or is it perhaps occurring outside of their awareness? Such questions are important because understanding the authentic differences between pre-and-post PANAS data is crucial for showing any affective changes that may have occurred in relation to the Project enhancement strategies.

Turning more broadly to the analysis of critical teaching moments, it is of interest that the "no enhancement" group tended to experience and report higher levels of positive emotion, and lower levels of negative emotion, than did the "enhancement" group. This was especially true for emotions relating to "Excitement/Enthusiasm", "Happiness", "Enjoyment", "Pride" and "Interested", which all represent positive forms of affect. Note also, however, that the no enhancement group self-reported much greater "Anxiety/Worry" than the enhancement group, even though this was observed as lower than the enhancement group by others. Perhaps what was occurring here was that a greater sense of "pressure" took place for PSTs undergoing enhancement – a type of performance pressure - while a sense of "missing out" took place for PSTs when they were not receiving enhancement. In either case, the question again arises as to whether an intentional or unconscious emotion-regulation strategy may be occurring to control emotional display and, if so, how this might be operating.

Ongoing Research

One of the clearest outcomes from this early analysis of the Project affect data is that some sort of emotion-regulation strategy seems to be occurring in relation to emotional display. In this respect ongoing research will need to investigate the degree to which PSTs are aware of such strategies, why certain emotions seem to be controlled in a more strategic manner than others, and how emotional regulation takes

place. Perhaps 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. In both cases the aim of improving PST emotional awareness, in terms of connecting the experience of distinct emotions to individual behavioural responses, would be further clarified.

Conclusion

The Project: "It's My Life" is a multi-institution STEM project, designed to increase the competence and confidence of training Mathematics and Science teachers. This report has focused on initial analyses of how the Project used affective measures as part of the iterative processes by which pre-service teachers (PSTs) explored and analysed the pedagogy connected to their teacher training. In these findings we can already see that the PSTs have exhibited a positive emotional bias overall, and also displayed greater changes in their negative versus positive emotions. These findings also suggest that when receiving enhancement for their lesson development (expert science or mathematics input, plus pedagogical guidance), the PSTs may feel pressure to perform, while when not receiving enhancement (developing their lesson in collaboration with other PSTs only) they may feel as though they are missing out on important information.

Early analysis of the Project survey supports the Project's emphasis on reflective affect analysis to increase pedagogical confidence, and thus links this training strategy to the larger Project goal of increasing competence through increasing pedagogical confidence. Importantly, differences between experienced (self-reported) affect and observed affect highlight the need to elaborate the reflective process in terms of consciously identifying the relationship between specific emotions and their behavioural correlates.

Overall, these findings indicate that the Project's use of affect analysis is appropriate as a means of addressing the lack of confidence and competence in science and mathematics teachers in Australian schools. Indeed, in this most essential criterion the Project seems to be hitting the targets it has set for itself quite well. 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 behaviour on the part of training STEM teachers. In this respect the Project will need to modify certain elements within the reflective process, and this is viewed as an important way forward for the ongoing Project program. The effect of these modifications will be to better connect emotional literacy to the Project research goals, in order to improve the overall Project goal of developing quality teaching practices that are directed at the enhancement of science and mathematics teaching in Australia.

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