



RESEARCH REPOSITORY

*This is the author's final version of the work, as accepted for publication following peer review but without the publisher's layout or pagination.
The definitive version is available at:*

<http://dx.doi.org/10.1007/s11422-014-9607-y>

Ritchie, S.M., Hudson, P., Bellocchi, A., Henderson, S., King, D. and Tobin, K. (2015) Evolution of self-reporting methods for identifying discrete emotions in science classrooms. *Cultural Studies of Science Education*, 11 (3). pp. 577-593.

<http://researchrepository.murdoch.edu.au/id/eprint/26463/>

Copyright: © 2015 Kluwer Academic
It is posted here for your personal use. No further distribution is permitted.

Evolution of Self-reporting Methods for Identifying Discrete Emotions in Science Classrooms¹

Stephen M. Ritchie, Peter Hudson, Alberto Bellocchi, Senka Henderson, Donna King,
Queensland University of Technology

and

Kenneth Tobin
City University of New York

Emotion researchers have tended to aggregate discrete emotions (e.g., happiness, anger, fear, sadness, surprise, pride, shame and guilt) into two valenced dimensions; that is, positive and negative (e.g., Stets, 2010; Thamm, 2007). For example, the valence of happiness is positive whereas the valence of fear and anger is negative (Turner, 2002). This [research](#) practice can be problematic because different processes drive each emotion, leading to different outcomes, and the capacity to tease out these differences is diminished (Gooty, Gavin, & Ashanasy, 2009).

Calls for future research to examine discrete emotions and how they vary over time (e.g., Gooty et al., 2009) has led to challenges in identifying, measuring and even distinguishing between emotion labels (Pekrun & Schutz, 2011). There is a paucity of research on discrete emotions, so this research is “quite necessary” (Gooty et al., 2009, p. 835) to help understand better the production of emotions in social contexts, particularly in science classrooms. Moreover, Pekrun and Schutz (2011) encouraged education researchers to adapt innovative methods in emotion research for educational contexts. In particular, they argued, “there is a need for adapting observational systems of emotions such that they can be integrated into video-based classroom studies, and be used for analyzing students’ and teachers’ ongoing emotions in classroom discourse” (p. 324).

Self-reporting methods such as questionnaires, interviews, and diaries have been the most commonly employed methods in emotion research (Gooty et al., 2009). Yet, issues with validity and reliability of self-reporting measures have raised concerns about their viability. For example, Pekrun and Schutz (2011) acknowledged that while self-reporting measures can be used, they have limited value in assessing the dynamics of emotions in real time. Other limitations identified include instrument design and administration; and participant bias, memory loss, uncertain access to consciousness, and self-deception or distortion of past events to portray themselves more favorably (see Do & Schallert, 2004; Pekrun & Schutz, 2011; Wosnitza & Volet, 2005).

In our ongoing research in science classrooms we use self-reporting methods along with other methods, including analysis of video, to help identify discrete emotions experienced by teachers and students, as recommended by Barker, Pistrang and Elliott (2002), Pekrun and Schutz (2011), and Wosnitza and Volet (2005). For example, Wosnitza and Volet

¹ Paper for discussion at the symposium "Expanding perspectives and participation in research on teaching and learning science with innovative methodological approaches," for the annual meeting of the National Association for Research in Science Teaching, Rio Grande, Puerto Rico, April 5-9, 2013.

(2005) asserted, “All these [self-reporting] methods have limitations. When used in combination these methods provide a more comprehensive picture of the emotion arousal process and its impact on the learning process” (p. 454).

This paper builds on a previous publication (i.e., Tobin & Ritchie, 2012) where we described a range of methods we had used in emotion research. By focusing on our innovations in self-reporting methods here we hope other researchers will continue to explore better ways to identify discrete emotions experienced by students and their teachers in education settings. Specifically, we track our use of innovative self-reporting methods in emotion research through three cases. The first case comes from a study of the emotional transition of beginning science teachers to full-time teaching (e.g., Ritchie, Tobin, Sandhu, Sandhu, Henderson, & Roth, 2013) where one of the teachers was asked to code her in-the-moment experienced primary emotions (i.e., happiness, fear, anger, sadness), from a video-recording of each lesson she had just taught, during a stimulated recall interview.

The second case was situated in a teacher education context at university where we were interested in identifying real-time emotions experienced by pre-service science teachers during lectures and workshops. In this case, pre-service teachers recorded their emotions at five-minute intervals using audience response devices or clickers. Yet, the range of emotions was constrained to six emotions we identified as most salient for this context (i.e., positive: Enthusiasm, Happiness, Attentive; Neutral; negative: Bored, Annoyed, Disappointed).

The final case used a list of 10 emotions that were considered most relevant to eighth grade science students by the same panel of researchers. Rather than relying on clickers for students to self report their experienced emotions, we asked students to complete an emotion diary at the end of each lesson in which they identified any emotions experienced and the details of the events that evoked such emotions.

Each of the cases discussed below uses innovative self-reporting measures integrated with video-analysis of students’ and teachers’ discourse and physical emotional responses in classroom interactions. After discussing the backgrounds and methodological implications of each case, we identify new directions for our continuing emotion research in science classes.

Case 1: Differentiating Between Fear and Anger in Stimulated Recall Interviews

We begin by illustrating a case in which a beginning science teacher (i.e., Fiona, a pseudonym) recorded her discrete emotions electronically as she reviewed video recordings of her science lessons in the context of stimulated recall interviews. Stimulated recall interviews typically involve a participant teacher replaying a video recording of a lesson as soon as possible after the lesson. In our case, Fiona paused the video whenever she recalled what she was thinking or feeling in various instances that she, rather than the researcher, identified. The researcher sought clarification and probed

her responses without asking leading questions. The general procedure and limitations of stimulated recall interviews have been elaborated elsewhere (e.g., Dempsey, 2010).

We adapted this form of self-reporting by asking Fiona to code emotional instances when she recalled feeling one of the four primary emotions. Coding was accomplished by pressing a hotkey (s=sad, h=happy, f=fear, and a=anger) on a laptop computer using StudioCode™ software. As Fiona coded instances of the primary emotions experienced during the lesson, she articulated how she felt and the reasons behind her feelings. Each instance captured a 10-second clip for later video analysis. Selected clips could be expanded to capture fully the beginning and end of a salient episode or event.

Each interview was video recorded and this was aligned with her teaching by creating two separate windows opened simultaneously (i.e., one of Fiona teaching and the other displaying her coding and reflecting on her emotions and her teaching), thus her commentary was linked directly to her teaching practice. Merging instances of the lesson with the associated segment from the interview created split screen video clips. Initially, selected clips were replayed at normal speed and then in slow motion. Classroom utterances were transcribed along with associated interview comments.

Recent research (e.g., Dael, Mortillaro, & Scherer, 2012) has demonstrated that body movement and facial expressions play important roles in emotion communication. For this reason, we recorded Fiona's non-verbal actions alongside the transcript. We applied Ekman and Friesen's (1978) Facial Action Coding System manually as well as eMotion Recognition 1.21 software to Fiona's facial images. Descriptions of the two relevant emotions expressed in the face for this case were: (1) Fear: lips are slightly opened, eyes are widened showing more of the sclera with eyebrows drawn closer and upward forming a wrinkled brow, (2) Anger: lips are pursed and eyes are narrowed with eyebrows drawn together and downward, forming vertical wrinkles between the eyebrows (Ekman & Friesen, 1975, 1978).

Analysis of vocal expression of emotion or prosody is another common method of analysis in emotion research (Dael et al., 2012). After capturing the sound track (or aiff file) from the video clips we conducted prosody analysis using PRAAT software (<http://www.praat.org>). In particular, selected prosodic characteristics of pitch (mean for F_0 and F_1 in hertz [Hz]), intensity (mean in decibels [dB]), and speech rate (syllables/sec) were identified for key expressions. Comparing these characteristics with neutral expressions revealed likely discrete emotions (cf. Scherer, 2003).

In addition to our microanalysis of videoclips, data were gathered from a 50-minute video-recorded cogenerative dialogue with three of Fiona's students whom she had taught for one year. These students commented on their reading of still images of the teacher's posture and gestures in the clips of interest. Cogenerative dialogue (or cogen) has been used widely to engage students actively in the design and execution of lessons to maximize their learning opportunities. Cogen is a reflective conversation about what happens in class, where members from the research team join the teacher and several selected students to discuss what works well and what improvements can be made (Tobin & Roth, 2005).

We now show how Fiona’s self-reporting in one event attributed a different emotion than other less inferential measures we adopted. This anomaly, and other practical issues identified, led us to begin our search for designing and adapting new self-reporting methods.

While reviewing a video replay of Fiona’s grade 7 science class during a post-lesson stimulated recall interview, Fiona recorded the emotion of fear in two different ways for one instance. Fiona pressed the computer hotkey “fear” and the StudioCode software tagged this 10-second segment as a fearful instance. Second, with only a 0.1s delay after pressing the key, Fiona commented: “I’m a bit anxious about this one you can see I have the grumpy face on ‘cos they’ve just been so psycho till the end of year, so I was a bit anxious about how it would go” (see Table 1). Anxiety is a low intensity version of the primary emotion of fear (Turner, 2002). Fiona claimed she experienced anxiety on two occasions in this comment that reinforced her coding of fear. Interestingly, she attributed her anxiety to her students’ “psycho” behavior, and admitted that this was not an isolated instance of this behavior. Under these conditions, it was completely believable that she was anxious prior to the class and at times during the class. Yet, Fiona’s “grumpy face” was more suggestive of anger. Micro-analysis of this 10-second segment, along with our search for both confirming and disconfirming evidence from multiple data sources, showed that all measures of the teacher’s emotional state indicated anger rather than fear.

Table 1. Fear or Anger?

Time & Studio code	Classroom observation	Interview	Prosody on teaching voice
00:02:10 FEAR	Most students are in or near their seats.		
00:02:20 00:02:62	Fiona stands with her left hand on her hip and the other hand on the front workbench. Her face appears expressionless. Most students are seated but actively involved in conversation within small groups. Fiona turns her head to her right “ <i>You’ve got about two seconds to shut your mouth and listen</i> ”. On the word “You’ve” students turn to face Fiona except two students right in front of her. One boy, named Joe, who was facing Fiona, turns his head to his peer. Fiona, with one hand on the hip and the other on the bench, looks to her far left with slightly pursed lips. There continues to be low level noise from students. Just after the words “...shut your mouth”, Joe lifts his right hand and covers his right ear. His peer (Robert) does not look at	“I’m a bit anxious about this one you can see I have the grumpy face on” (in the interview she produces a single laugh “huh” and tucks back hair behind her left ear then places elbow on table and right hand with fingers curled on cheek). “Cause they’ve just been so psycho till the end of the year, so I was a bit anxious about how it would go” (has her arms folded then places left	Pitch on the word “listen” in “shut your mouth and listen” $F_0 = 333$ Hz $F_1 = 737$ Hz Intensity = 75 dB
00:05:10			

Fiona during this talk but rather engages hand on mouth).
 more with Joe, who was half standing and
 shifting towards Robert.

Speech Rate
 = 5.2 syll/s

00:07:92

After the observation period we conducted a cogenerated dialogue with the teacher and a group of students from her class because students are known to be good observers of teachers' actions (Sutton, 2007). In this cogen the students identified Fiona's typical angry behavior as follows:

Student 1: That she (Fiona) starts raising her voice.

Student 2: She stops leaning on stuff.

Student 3: Yeah and hands on your hips.

Student 2: Coz you'll be like leaning on stuff and like in this photo here you'll be like leaning and once you get cranky you're up straight.

Student 3: You're much more alert.

Student 1: Class talking at the same time and then you go "oh now block your ears, she's gonna yell".

The video recording prior to the clip represented in Table 1 showed Fiona standing behind the front bench in a position of assertiveness-anger as the students entered the classroom. As the students had indicated in the cogen, Fiona's body language (i.e., erect body position with hand on hip) signalled anger. When the students entered the classroom they averted Fiona's eyes, indicating that they through their actions they had read her stance as angry.

Fiona's anger during the clip in Table 1 was determined through analysis of multiple data sources. In relation to her facial expressions, her lips were tightened and narrowed with the corners drawn down during the utterance: "You've got two seconds to shut your mouth and listen." The application of the eMotion software during the statement showed that Fiona's emotional expression peaked at 85% anger. The utterance itself was emotionally charged in the form of a stern warning that was read by students as an angry command by their subsequent actions (i.e., two students in the front row rotated their heads away from the source of the comment, and the class became silent), and recalled later in a cogen. Prosody analysis also indicated a higher intensity and pitch during this utterance than previous teacher comments, which was indicative of anger (i.e., with respect to neutral emotional responses, there were elevated measures of F_0 , F_1 , Intensity, and speech rate; cf. Scherer, 2003).

Even though we explored alternative interpretations, the most probable explanation for the complete data set was that Fiona was angry in-the-moment of her classroom utterance yet was anxious prior to and following the instance, and possibly fearful of how the utterance would be interpreted by the researchers. Teachers have difficulty differentiating between fear and anger because they often are fearful of the expression of anger itself (Liljestrom et al., 2007).

The implications from our initial work with teacher self-reporting of emotional states have informed the development of innovative methods as we expand our focus to measure student emotions, both science students in classrooms and pre-service teachers in university classes. We do not rely on self-reporting as the sole method of identifying emotional states. As well, we have expanded the range of emotional states beyond the primary emotions measured, increased the frequency of required responses, and decreased the time delay between the emotional event and recording the emotional state (cf. Linnenbrink, 2007). Multi-method approaches with further refinement of the measurement of emotions are needed to advance the field of research on emotions in education (Pekrun & Schutz, 2011). We now turn to our second case.

Case 2: Limited Differentiation of Experienced Emotions Recorded by Clickers

In our continuing study of the quality of pre-service science teaching and learning (e.g., Ritchie, Bellocchi, & King, 2013), we have adapted audience response technology so that pre-service teachers recorded their perceptions of experienced discrete emotions at regular intervals during classes across a semester. This work built on our previous research with this technology to measure pre-service teachers' perceptions of the emotional climate in science education classes (see Bellocchi et al., 2013). Emotional climate is the collective state of emotional communion between members of a group or organization in which members' salience of self decreases as their collective identity is enhanced (Kanyangara, Rime, Philippot, & Yzerbyt, 2007). In that research, we measured emotional climate (EC) by inviting participants to input their perceptions using numbered keypads (or clickers) on a five-point scale (i.e., 5 = Very positive EC, 4 = Positive EC, 3 = Neutral EC, 2 = Negative EC, 1 = Very negative EC) at 3-minute intervals, signaled by a bell. These scores were relayed to a laptop computer in the room via Bluetooth technology so that class averages for each interval could be calculated and graphed as the lesson progressed. Peaks and valleys in the graphs were used heuristically to identify classroom events. That is, we identified events in video data of class interactions based on the time intervals corresponding to peaks and valleys in the graph. As in Case 1, discrete emotions expressed by participants in the video data were identified through facial expression analysis (Ekman, 2004), and analysis of prosody and proxemics (or body movement and gestures). We also employed cogenerative dialogue. Specifically, we conducted five cogens throughout the semester with different combinations of volunteer pre-service teachers.

In the current case, we adapted the EC application of the clickers by assigning keypad numbers to discrete emotions. Six emotions were identified by a panel of seven emotion researchers through a process of reducing a list of emotion labels associated with

academic contexts obtained from such instruments as PANAS (Positive Affect Negative Affect Schedule; Watson, Clark, & Tellegen, 1988) and AEQ (Academic Emotions Questionnaire; Pekrun, Goetz, Titz, & Perry, 2002) until there was agreement on the most likely emotions pre-service teachers would be expected to experience. The positive emotions of Enthusiasm, Happiness, and Attentiveness were allocated to keypads 1, 2, and 3, respectively. The negative emotions of Boredom, Annoyed, and Disappointed were allocated to keypads 7, 8, and 9, respectively. A neutral option was allocated to keypad 5 should the pre-service teachers not experience an emotion, or it was too low in intensity for it to be identified, in any interval.

Figure 1 illustrates a typical pattern of recorded discrete emotions in a lecture. The most frequently recorded emotion was attentiveness (green). This was followed by neutral (purple). We were surprised by this pattern because we expected greater diversity of responses from the pre-service teachers. Even though some pre-service teachers selected enthusiasm and happiness, boredom and annoyed were not selected by any pre-service teacher during the lecture. However, as we discovered in the cogens, many pre-service teachers adopted a default position by pressing the attentiveness or neutral keypad for each interval. As one pre-service teacher (PST) admitted: “Well I guess most of the time I just press attentive because I’m trying to listen... trying to concentrate on what is going on in class but I may not always feel that emotion” (PST 1). Interestingly, as the conversation between pre-service teachers continued where PST 2 suggested that she too pressed the number 3 because she did not remember the number for bored, PST 1 adds, “yeah, it’s like the default button.”

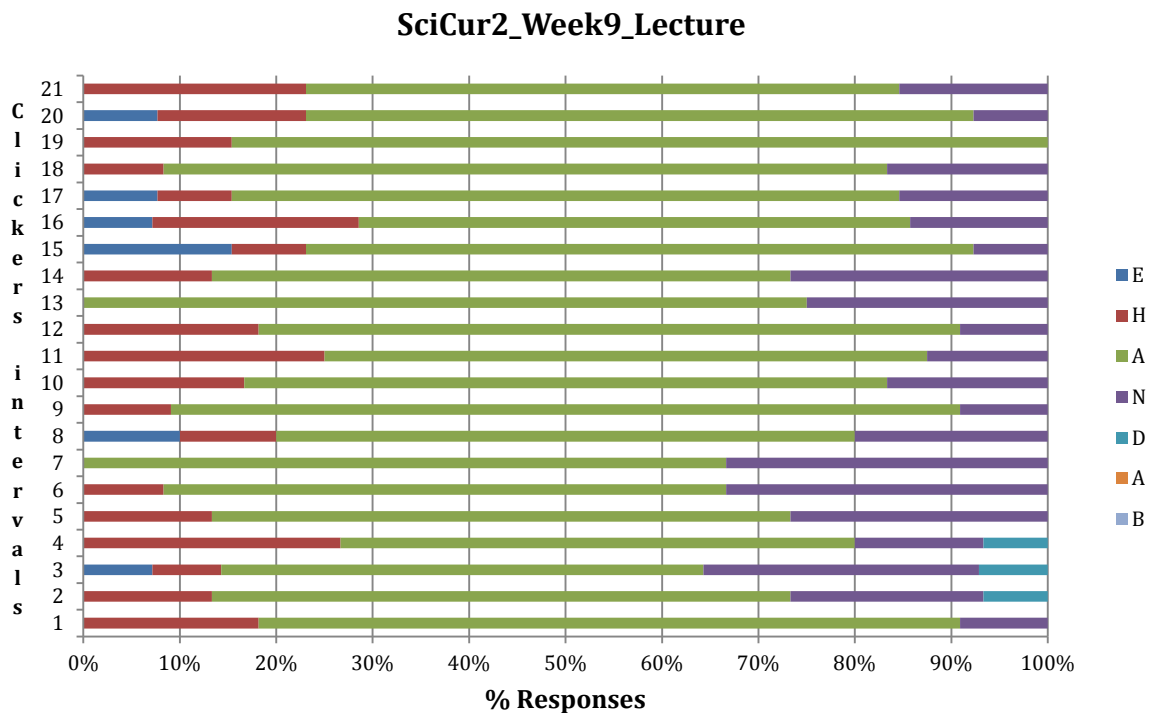


Figure 1: Pre-service teacher responses in 5 min. time intervals

An additional default button was identified in the continuing conversation, as follows:

PST 3: Wouldn't 5 [purple] be the default? The middle.

PST 4: Yeah 5 is my default.

Ritchie: Well that would account for the purples [neutral] ((laughter from PSTs 1, 2 & 5)).

PST 1: It should be I guess.

PST 2: I never really thought.

PST 1: No, I'm the same, I just press 3 [green].

Having two default buttons identified (i.e., attentiveness and neutral) that pre-service teachers selected without too much consideration in many intervals, raises concerns about the reliability of this method of self-reporting of discrete emotions experienced in-the-moment.

Another concern related to the patterns displayed in Figure 1 is revealed in intervals 2, 3, and 4. Here, one pre-service teacher (i.e., PST 5) pressed button 9 for disappointed on three occasions over this 15-minute period. This was rarely recorded throughout the course so it caught our attention. Viewing the video recordings showed PST 5 in a somewhat distressed state with her hands on her face, supporting her head, as shown in Figure 2. PST 5 accounted for her responses during the cogen by admitting, "I pressed disappointed yesterday, but it wasn't due to the class. It was due to the class before." In the preceding class, several pre-service teachers had received grades for a completed assignment, and some had achieved less than they had expected. They had discussed their disappointment prior to this class. Even though other disappointed pre-service teachers did not record this emotion during the lecture, PST 5 sustained the emotion for considerable time. In terms of Bourdieu's field theory (e.g., Bourdieu, 1977), where fields are borderless entities that can overlap or intersect in such a way that the emotions experienced in one field can impact on the emotions in another, it is unsurprising that one of these pre-service teachers (i.e., PST 5) carried with her disappointment from her prior class. This has implications for the reliability of self-reporting of emotions related to a particular event.



Figure 2: Image of PST 5 feeling disappointed

We have two further and related technical issues with this method that could be addressed in subsequent measures. The first relates to the interval sampling. On the one hand some pre-service teachers suggested in cogens that the sound of the bell at the end of each interval refocused their attention after being “zoned out,” yet others felt somewhat annoyed with the interruption. Despite feeling annoyed at hearing the bell, those pre-service teachers who expressed annoyance in the cogens did not record this emotion with the clickers. The related issue is that pre-service teachers were constrained by selecting just one emotion during the interval. There are two problems here. The first problem is that pre-service teachers may experience multiple emotions within an interval as large as three to five minutes, so any selection will not be an accurate recording of their emotions over the interval. The second problem is that pre-service teachers need to choose whether the most intense or most recent emotion is selected. This dilemma was acknowledged by PST 1 as follows: “I think, PST 3 mentioned it before, when the bell goes off you’ve missed your emotion or you are kind of back to neutral its like they don’t well I know its intervals every 5 minutes but sometimes there are spikes in the lesson where particular things happen or I feel like that was really cool I’m enthusiastic but by the time the bell rings I’m just back to neutral.”

Based on these experiences, we are less inclined to invite students to identify discrete emotions at three or five minute intervals using audience response technology in future studies. Rather, if we simply want to identify events for microanalysis of video-data, it would be more effective to revert to our previous method of rating the emotional climate on a five-point scale (cf. Bellocchi et al., 2013). A complementary method we could add might be the use of an emotion diary.

Case 3: Refining Emotion Diaries for Students

In Zembylas’s (2002) three-year ethnographic study of an elementary school science class, the teacher (i.e., Catherine) entered her emotional experiences in an emotion diary at the end of each day. The purpose of the diary was to help Zembylas determine how the teacher’s emotions influenced her science teaching, pedagogy, and professional and

personal growth. The diary template prompted the teacher to respond to up to 14 questions or tasks. The first task requested the teacher to identify which emotions from a list of 21 emotion labels were experienced during the day. Some subsequent tasks requested the teacher to describe each event that corresponded to the identified emotion, and to indicate the intensity of the emotion.

Studies of adult learners have used emotion diaries to access students' emotions during the learning process. Even though this method does not provide direct access to in-the-moment emotional experiences, depends on the cooperation of the participant to disclose emotions, and is reliant on self-reporting (Wonitza & Volet, 2005), Zembylas (2008) argued that the personal nature of diaries brought attention to the learners' emotion talk that were not evident from other sources.

In our ongoing study of high school science students' emotional engagement with socioscientific issues² in classrooms (see Ritchie & Tomas, 2013), we adapted Zembylas's emotion diary template for our younger participants to enrich and complement the data sources we had used. In particular, we modified the template in five ways. First, we designed the template so that the reduced set of tasks was confined to only one page. Second, the template was reduced to a list of 10 emotion labels, besides each students were encouraged to identify the classroom circumstances that evoked the arousal of this emotion. A panel of researchers identified the most salient list of emotions for 8th grade students. Only the emotion of embarrassment was imported from another instrument (i.e., AEQ, Pekrun et al., 2002). The 10 emotion labels were: happiness/joy, sadness/disappointment, anger/irritation, anxiety, disgust, pride, wonder, enthusiasm, frustration, and embarrassment. Third, in anticipation of students' confusion of some less familiar labels, an emoticon for each label was added. Fourth, because we were aware that some researchers disputed the classification of interest and boredom as emotions, we nevertheless thought they were sufficiently important to include as separate indicators of the students' engagement in the lesson after the list of 10 emotions. Fifth, we invited students to complete an emotion diary at the end of each lesson. This meant we could access over 220 8th grade students' diaries for 30 lessons that also were video-recorded.

Unsurprisingly, the novelty of recording emotions for students waned as the study progressed and it was difficult for some teachers to allocate sufficient time for students to complete entries. This had the effect of reducing detail over time. It appeared only the most intense emotions experienced were recorded and described. Students reported positive emotions such as happiness and enthusiasm regularly yet very few negative emotions. When emotional events were described, we replayed the video recordings, isolated the events and conducted microanalyses of the conversations, gestures and facial expressions. To illustrate how we analyzed multiple data sources in identified events, we select an event in which the discrete emotion of disgust was the focus. We do so because it was an infrequently experienced emotion in the science classes involved in this study, the absence of which has been noted in other classroom studies (see Pekrun, Goetz, Titz,

² Socioscientific issues such as organ harvesting are significant social issues and problems with conceptual or technological links to science (see Tomas & Ritchie, 2012).

& Perry, 2002). Moreover, disgust is a negatively valenced emotion that we have not previously investigated, and as shown below, it highlights the importance of inventing new methods to interpret data in nuanced ways in naturalistic settings.

Disgust is revulsion; primarily at the prospect of taking in orally an offensive object such as contaminated food or even an offensive smell (Rozin, Haidt & McCauley, 2008). Poor hygiene, body excrements (e.g., urine, vomit, feces), death, and violations of the ideal body ‘envelope’ or exterior body form (e.g., obesity, deformity, wound or injuries) and moral codes such as repugnant sexual acts also can trigger the expression of disgust (Rozin et al., 2008; see also, Turner & Stets, 2007). Mild disgust is likely to be expressed as nose wrinkling, with raised upper lip and relaxed eyebrows (Ekman, 2004). Stronger expressions of disgust would lead to more intense nose wrinkling with further rises in upper lip but with eyebrows drawn downwards (Ekman, 2004), and this could be associated with a gesture of pulling away or guarding oneself against an offensive object (Darwin, 1890).

Diary entries from three female students in one class indicated the presence of disgust in week 4, lesson 2. The unit of work undertaken during this term was on the socioscientific issue of organ transplants and harvesting. In the lesson that evoked the expression of disgust, the teacher was showing graphical images of skin grafts following full thickness burns. The diary entries included: “Skin grafting video” (Student 1—see Figure 3) and “At the pic of da nose that looked like a trampoline” (Student 5—not captured in Figure 3). The latter comment emphasized the appearance of grafted skin, in this case over the nose.

Replaying the video recordings of the lesson from different cameras in this classroom located the precise moment where at least four girls expressed disgust at images of skin grafting. Figure 3 shows the facial images of three girls captured in the same frame at different levels of disgust. The image of the girl in the center of the frame (i.e., Student 2) shows classical signs of mild disgust with the nose wrinkled, upper lip separated, but with relaxed eyebrows. Student 1 on the left shows wrinkled nose, lips and eyebrows, which were even more pronounced over the face of Student 4 on the right. Ekman (2004) also found that films of people suffering from the medical treatment of third degree burns produced the expression of disgust in laboratory studies. The powerful images in Figure 3, however, were recorded in a real classroom—setting it apart from most recorded images of disgust involving actors or those captured during psychological experiments.



Figure 3: Facial expressions of disgust

The image of the boy (i.e., Student 3) shows an expression that initially could be interpreted as a joyful or happy experience. Yet, Rozin et al. (2008) have noted that disgust plays a central role in the humor of adolescent males who can take advantage of disgusting aspects of the human body to confront adult norms and establish status within their peer group. Clearly, there may be gender differences with the expression of disgust in coeducational classrooms. Alternative interpretations of his reaction could be that he took pleasure out of avoiding his expression of disgust in the conscious attempt to elevate his status within the class or he somehow masked his experience by a happy expression. Whereas it is possible for people “to modify how they feel” through “emotion regulation that involves conscious and unconscious attempts to modify” emotions (Sutton, Mudrey-Camino, & Knight, 2009, p. 131), there was no way to determine empirically from the available data in this event Student 3’s actual emotions captured in the moment nor his motives for his expression. Unsurprisingly he did not register the emotion of disgust but listed his experience of happiness in his diary without any elaboration to indicate whether this event was the one that gave him happiness.

Even though we found moderate to high positive correlations between interest and happiness / enthusiasm (cf. Linnenbrink, 2007) across the classes involved in the study (i.e., $r=.67$), happiness alone was not an indicator of interest in the topic in science classes for several students in particularly confronting events. As it happened, Student 3 in Figure 3 rated the lesson low in interest (i.e., 4/10). In contrast, despite showing disgust in the moment, two of the girls captured in Figure 3 (i.e., Students 1 and 4) recorded maximum scores for interest in this lesson (i.e., 10/10). In other words, it is possible to experience disgust yet be highly interested in the topic of the lesson, just as it is possible to experience happiness in a lesson that is not particularly interesting. Importantly, this highlights one of our introductory remarks that research to identify discrete emotions is important work; we cannot assume that even though positive emotions may be desirable for learning (Schutz & Pekrun, 2007), some negative emotional experiences can afford opportunities for learning. As we have identified here, the link between discrete emotions

and learning is much more nuanced than generalizations such as positive emotions are good and negative emotions are bad.

Completing emotion diaries at the end of each lesson proved to be a nuisance for participants. Yet, it was very useful for our research goals because it identified events within lessons that evoked strong discrete emotional responses to the subject matter. We now agree with Zembylas that the method is useful in identifying individual differences in emotional experiences within classrooms. For this reason, we plan to persevere with the method. To help reduce the perceived load of completing the task each day, we will emphasize the importance for students to identify their strongest emotional experiences during each lesson. Implications of this realization and prospects for further refinement of our methods are now considered.

Implications for Our Ongoing Research

The two most revealing and reliable self-reporting methods we have used in our emotion research with students are emotion diaries and cogenerative dialogue. In particular, these methods have been helpful in identifying classroom events from video-recordings that can then be micro-analyzed by other methods, as illustrated in the three cases. Used with video-analysis, as recommended by Pekrun and Schutz (2011), they provide contextual background and insights into the emotional experiences of students, and the indicators of emotional expression by their teachers. Whereas cogens have universal appeal in teacher education and school classrooms, and will continue to be used in subsequent studies, the design of emotion diaries will need to be different for these contexts. The variations to the emotion diary templates we are planning for studies in these different contexts are now identified.

Emotion diary for teacher education classes

White (2013) recently validated a 14-item instrument to assess Australian higher education students' emotions related to academic performance. He identified three factors, with six items for positive emotions loading on factor 1 (i.e., enjoy, happy, excited interest, engaged, hope), five deactive emotions loading on factor 2 (i.e., worry, nervous, pressure, scared, stress), and five active negative emotions loading on factor 3 (i.e., annoyed, angry, frustrated, disappointed, bored). Even though the 276-strong sample was adequate for the analysis, information was not supplied to indicate what proportion of this sample was undertaking programs in pre-service teacher education. Nevertheless, several of the emotions identified have featured in our studies, suggesting this instrument could be a useful guide for subsequent refinements to the design of emotion diaries.

Pre-service teacher education traditionally has been conducted face-to-face in lecture halls and tutorial rooms. Increasingly, it is becoming more common to offer programs to students online. This trend provides new challenges for existing methods for recording and analyzing emotional expression (e.g., Wosnitza & Volet, 2005). It may very well be difficult to video-record online student work, but this should be the preferred method for emotion research, supplemented by other methods canvassed by Wosnitza and Volet

2005), including emotion diary. Yet, with the exception of two studies of pre-service teachers—one conducted in an introductory technology integration course (Borup, West & Graham, 2012) and the other that focused on emotional exchanges during teaching practice placements (Gleaves & Walker, 2010)—online pre-service teacher learning has escaped much attention by emotion researchers. Even though our current research has been conducted in face-to-face classroom settings on campus, any new designs for emotion diaries should be sufficiently resilient for application in online delivery modes.

Discrete emotions identified by a small-scale interview study into emotions of learners in higher education included: frustration, anxiety, enthusiasm, pride, and to a lesser extent, shame / embarrassment (O'Regan, 2003). Frustration, anxiety and pride, along with interest (cf. case 3) should be added to our existing list of emotions in the design of new emotion diary templates. Furthermore, White (2013) argued bored and nervous should be removed from his list due to statistical anomalies, and that the deactive negative emotions were not significantly associated with course satisfaction so they could be removed without detracting from his model's attractiveness. The deactive positive emotion in factor 1 (i.e., hope) should then be removed for theoretical consistency. In relation to our previous list of emotions, it would seem prudent to remove default selections (i.e., attentiveness, neutral—case 2). The removal of “engagement” (cf. White, 2013) is justified on similar grounds; that is, like attentiveness, it could be another default option. The only other emotion from White's list we have not included is angry for two reasons. First, it was never identified in case 2 by our PSTs, and second, should this strong emotion ever be experienced—as for shame—the addition of the separate category of “other” in the diary would afford PSTs the opportunity to record this or new labels that match their experienced emotional arousal in class. This leads to the identification of nine emotion labels and an additional category that should be included in subsequent emotion diaries; namely, Excitement, Happiness, Enjoyment, Pride, Interest, Anxiety, Frustration, Annoyed, Disappointment, Other.

As with case 3, teacher education students will be invited to complete an emotion diary at the end of each session (lecture and tutorial) to indicate which emotions they experienced, and the circumstances of those experiences (e.g., who or what caused their annoyance and when this occurred?). These data will be used heuristically to identify salient events for microanalysis. For studies involving online learning, students will be invited to complete an emotion diary at the conclusion of each session. This could include reading assigned articles, viewing streamed video-recordings of on-campus lectures, online interactions with students and lecturer on blogs, and undertaking assessment requirements.

Emotion diary for high school students

The template for the high school student diaries should be largely unchanged. The minor changes will simplify the task for students by requiring them to identify the circumstances for only their strongest emotional events during the class. Students also will be asked to give an overall rating for each lesson of the extent to which they experienced interest and boredom, and the triggers for these ratings.

During Case 3 we found that most students expressed confusion with the meaning of the emotion label of ‘wonder’. Student comments suggested they took this to mean puzzled or confused. This has two implications for the design of future templates. First, this label will be deleted and replaced by the ‘other’ category to offer a free response option, as for the adult version. Second, classroom researchers will need to allocate time at the beginning of future studies to clarify the meaning of emotion labels. Examples of helpful explanatory comments also might be helpful to students so as events and direction of emotions are more readily identified.

Emotion diary for teachers

We first became aware of the potential of emotion diaries to provide insights into teachers’ emotional arousal through the research of Zembylas (e.g., 2002). Rather than engaging teachers in the time consuming practice of coding video-recorded lessons during stimulated recall interviews (case 1), subsequent studies of teachers’ emotions we undertake will include emotion diary as a key self-reporting method—used in conjunction with other methods (e.g., Tobin & Ritchie, 2012). Based on our experience in multiple contexts, the design of teacher emotion diaries will be similar to that which we have recommended for pre-service teachers; that is, a list of 10 emotions for which teachers describe the event that evoked each emotion. This method would be helpful in identifying events for detailed microanalysis of relevant videoclips.

Conclusion

Rather than glossing over important differences in sources, direction and outcomes of discrete emotions, we have complemented our primary analysis of video-recorded classroom interactions with the use of an evolving suite of self-reporting methods to identify discrete emotions. In this paper, we have illustrated adaptations we have made to identify less frequently reported classroom emotional expressions of fear, anger, disappointment, and disgust.

Emotion diaries and cogenerative dialogues are two self-reporting methods that will continue to complement our microanalysis of video-recordings of student learning in teacher education and high school science classes. We are hopeful that improvements in the application of these methods will provide greater insights into the role discrete emotions play in student engagement and learning in formal lessons. These data are likely to answer significant questions relating to emotional arousal in learning. Just as importantly, this research is likely to focus attention on increasing teacher awareness of student emotional arousal so that appropriate and timely teacher responses to students’ expression of emotions encourage students to experience success in classrooms so that they will actively seek to repeat their success in subsequent lessons. As this research unfolds, additional experiences are likely to lead to fine-tuning current methods, and explore innovative methods and new combinations of methods.

References

Baker, C., Pistrang, N., & Elliott, R. (2002). *Methods in clinical psychology: An introduction for students and practitioners*. West Sussex, England: John Wiley & Sons.

Bellocchi, A., Ritchie, S. M., Tobin, K., King, D., Sandhu, M., & Henderson, S. (2013, April). Emotional climate in pre-service science teacher education. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Rio Grande, Puerto Rico, April 5-9, 2013.

Borup, J., West, R. E., & Graham, C. R. (2012). Improving online social presence through asynchronous video. *Internet and Higher Education, 15*, 195-203.

Bourdieu, P. (1977). *Outline of a theory of practice*. Cambridge, MA: Cambridge University Press.

Dael, N., Mortillaro, M., & Scherer, K. R. (2012). Emotion expression in body action and posture. *Emotion, 12*, 1085-1101.

Darwin, C. (1890). *The expression of emotions in man and animals*. London, England: Penguin.

Dempsey, N. P. (2010). Stimulated recall interviews in ethnography. *Qualitative Sociology, 33*, 349-367.

Do, S. L., & Schallert, D. L. (2004). Emotions and classroom talk: Toward a model of the role of affect in students' experiences of classroom discourse. *Journal of Educational Psychology, 96*, 619-634.

Ekman, P. (2004). *Emotions revealed. Understanding faces and feelings*. London: Phoenix.

Ekman, P. & Friesen, W. V. (1975). *Unmasking the face*. Englewood Cliffs, NJ: Prentice-Hall.

Ekman, P., & Friesen, W. V. (1978). *The facial action coding system: A technique for the measurement of facial movement*. Palo Alto, CA: Consulting Psychologist Press.

Ekman, P., & Friesen, W. V. (2003). *Unmasking the face: a guide to recognizing emotions from facial expressions*. Cambridge, MA: Malor Books.

Gleaves, A., & Walker, C. (2010). Student teachers' situated emotions: a study of how electronic communication facilitates their expression and shapes their impact on novice teacher development during practice placements. *Teacher Development, 14*(2), 139-152.

Gooty, J., Gavin, M., & Ashkanasy, N. M. (2009). Emotions research in OB: The challenges that lie ahead. *Journal of Organizational Behavior, 30*, 833-838.

Kanyangara, P., Rime, B., Philippot, P. & Yzerbyt, V. (2007). Collective rituals, emotional climate and intergroup perception: Participation in "Gacaca" tribunals and assimilation of the Rwandan genocide. *Journal of Social Issues, 63*, 387-403.

Liljestrom, A., Roulston, K., & deMarrais, K. (2007). "There's no place for feeling like this in the workplace": Women teachers' anger in school settings. In P. A. Schutz & R. Pekrun (Eds.), *Emotion in education* (pp. 275-291). Oxford, UK: Academic Press.

Linnenbrink, E. A. (2007). The role of affect in student learning: A multidimensional approach considering the interaction of affect, motivation, and engagement. In P. A. Schutz & R. Pekrun (Eds.), *Emotion in education* (pp. 107-124). Oxford, UK: Academic Press.

O'Regan, K. (2003). Emotion and e-learning. *Journal of Asynchronous Network Learning*, 7(3), 78-92.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist*, 37(2), 91-105.

Pekrun, R., & Schutz, P. A. (2011). Where do we go from here? Implications and future directions for inquiry on emotions in education. In G. D. Phye, P. A. Schutz, & R. Pekrun (Eds.), *Emotion in education* (pp. 313-331). San Diego, CA: Academic Press.

Ritchie, S. M., Bellocchi, A., & King, D. (2013, August). Transformation of emotions by science teacher educators co-researching learning and teaching. Paper to be presented at the annual conference of the Australasian Science Education Research Association, Wellington, NZ.

Ritchie, S. M., Tobin, K., Sandhu, M., Sandhu, M., Henderson, S., & Roth, W.-M. (2013). Emotional arousal of beginning physics teachers during extended experimental investigations. *Journal of Research in Science Teaching*, 50, 137-161.

Ritchie, S. M., & Tomas, L. (2013). Designing an innovative approach to engage students in learning science. The evolving case of hybridized writing. In L. V. Shavinina (Ed.), *The Routledge international handbook of innovative education* (pp. 385-395). Oxford, UK: Routledge.

Rozin, P., Haidt, J., & McCauley, C. R. (2008). Disgust. In M. Lewis & J. Havilland-Jones (Eds.), *Handbook of emotions* (3rd ed.) (pp. 2200-2262). New York: Guilford Press.

Scherer, K. S. (2003). Vocal communication of emotion. A review of research paradigms. *Speech Communication*, 40, 227-256.

Schutz, P. A., & Pekrun, R. (Eds.). (2007). *Emotion in education*. Amsterdam: Academic Press.

Stets, J. E. (2010). Future directions in the sociology of emotions. *Emotion Review*, 2, 265-268.

Sutton, R. E. (2007). Teachers' anger, frustration, and self-regulation. In P. A. Schutz & R. Pekrun (Eds.), *Emotion in education* (pp. 259-274). Oxford, UK: Academic Press.

Sutton, R. E., Mudrey-Camino, R., & Knight, C. C. (2009). Teachers' emotion regulation and classroom management. *Theory into Practice*, 48, 130-137.

- Thamm, R. A. (2007). The classification of emotions. In J. E. Stets & J. H. Turner (Eds.), *Handbook of the sociology of emotions* (pp. 11-37), New York: Springer.
- Tobin, K., & Ritchie, S. M. (2012). Multi-method, multi-theoretic, multi-level research in the learning sciences. *Asia-Pacific Education Researcher*, 21, 117-129.
- Tobin, K., & Roth, W. -M. (2005). Coteaching/cogenerative dialoguing in an urban science teacher preparation program. In W-M Roth & K. Tobin (Eds.), *Teaching together, learning together* (pp. 59-77). New York, NY: Peter Lang.
- Turner, J. H. (2002). *Face to face. Toward a theory of interpersonal behavior*. Stanford, CA: Stanford University Press.
- Turner, J. H., & Stets, J. E. (2007). Moral emotions. In J. E. Stets & J. H. Turner (Eds.), *Handbook of the sociology of emotions* (pp. 544-566). New York: Springer.
- Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54, 1063-1070.
- White, C. J. (2013). Higher education emotions: a scale development exercise. *Higher Education Research & Development*, 32, 287-299.
- Wosnitza, M., & Volet, S. (2005). Origin, direction and impact of emotions in social online learning. *Learning and Instruction*, 15, 449-464.
- Zembylas, M. (2002). Constructing genealogies of teachers' emotions in science teaching. *Journal of Research in Science Teaching*, 39, 79-103.
- Zembylas, M. (2008). Adult learners' emotions in online learning. *Distance Education*, 29(1), 71-87.