Investigating emotional intensity in mathematics classrooms: an enhanced methodology or affective gimmickry?

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One known issue when working with emotions in context is the challenge of observing what are often transitory, fluid, and unconscious emotions, that vary in intensity and valency, and can change depending on when or who is asking. This paper reports on how one physiological measure, a simple galvanic skin response (GSR) sensor, which has become possible to use in class due to technological advances, can be used in conjunction with other methods such as observation and stimulated recall interview and can give insight into variations of a mathematics teacher's emotional intensity as they interact with students. The addition of physiological data to a common form of methodology provided useful prompts for teacher reflection and hence has potential for supporting development and is potentially a powerful addition to more common methodologies.

Keywords: Emotions, Intensity, Teachers, Physiological data, Mathematics.

Introduction

This paper discusses a method for examining emotional intensity in mathematics lessons, addressing this challenge through the incorporation of physiological data in addition to more common methods. Pekrun (2018) lists five ways to assess emotions; self-report, implicit assessment, neuro-imaging, behavioural observation (e.g. facial or postural expression) of emotionality (De Simone, 2015), and peripheral physiological analysis. In this paper, the focus is on incorporating the use of Galvanic Skin Response (GSR) to the study, a physiological measure applicable to studying intensity of emotions. There are studies of undertaking Mathematical tasks whilst being measured for heart rate and temperature, however measuring GSR is less intrusive than, for example, heart rate.

The wider study originated from a desire to explore how experienced teachers (past the emotional transition of training) use emotions, particularly positive emotions, within the social interactive context of teaching. There is evidence that exposure to positive emotions supports recall (Titsworth, McKenna, Mazer & Quinlan, 2013). Whilst, from a student perspective, Mottet & Beebe (2000) suggest that affect directly determines time spent on a task. Additionally, experiencing a social environment that includes emotions such as enthusiasm (Kunter et al., 2008), is likely to encourage perseverance and engagement. Early in the investigation of affective practices, I realised that little is known about the use, or the degree of intensity of emotional expression, but that emotional intensity and engagement are closely associated.

The data comes from experienced secondary mathematics classroom teachers in the UK. The method is illustrated by two teachers from the same school, Carol and Debbie, both deemed 'good' teachers by the school, in that they both have a strong rapport with students. The full research design incorporated that emotions are transitory, that they depend on context and evocation, and explored what teachers bring to the classroom (through pre-observation interviews), interaction (through videoed and audio-recorded lessons), and how teachers perceived the interaction (through

stimulated recall interviews). The method was designed to explore the use of positive emotions when teaching mathematics and to examine whether teacher affective interpretations match the observer perceptions. Embedding the element of GSR measurement offers an additional means of gauging intensity of emotions. This paper aims to show how a measurement of intensity can be incorporated into contextual emotion research, and to identify advantages of such incorporation.

Definitions and the wider context

Emotion can be conceptualised as energy that boosts cognitive functioning; energy that moves back and forth between individuals and the social. Emphasising the intensity of emotions, Lakoff and Johnson (1999) consider emotion is "…better understood as the tension of excitement level produced by the interaction of brain processes of perception, expectation, memory and so forth" (p. 176). The physical temporality emphasised by this definition is appealing as incorporative of the complexity of emotions. I retain the term emotion for use 'in-the-moment', as identifying the fluid and transitory nature of emotions. The energy definition seems applicable to the study of intensity within the dynamic and complex context of classroom teaching. Especially, as Graham and Taylor (2014) note, "[e]motions, then, can be a filter through which the perceiver may make rapid judgements in situations where there is much ambiguity" (p. 115). It seems reasonable that emotions as a filter would elicit internal intensity and the study was designed to capture such intensity. An experienced teacher often intervenes by instinct, as part of apparently effortless 'expert' teaching, and that the intensity of such an instinctive reaction may be internalised. Yet Kahneman (2011) suggests that changing a task, especially rapidly, is effortful. At such points, a teacher might increase their internal engagement, and hence an internal indicator such as skin conductance would show change, as emotional intensity increases. Barsade (2002) confirms that stronger emotions are more effective in communicating emotion, perhaps even with negative valence, as higher energy draws more attention.

The surge of physiological data in social sciences and education

Technologies that support the use of physiological data are becoming more accessible and portable, yet the use of GSR in active contexts remains sparse, usually taking place as study of individuals under static laboratory conditions. For example, within biological psychology, the use of skin conductance is common, with studies ranging from ADHD in boys to antisocial and violent behaviour, whilst many studies involve children where self-reporting is potentially less reliable. However, the application is now wider than sciences. For example, Oxley et al. (2008) suggest that political views have a biological basis. The physiological measures used include measuring change in skin conductance whilst participants were exposed to threatening or non-threatening images. Intriguingly, they found that, for participants with strong political views, lower physical sensitivities correlated with being more likely to support foreign aid, liberal immigration policies, pacifism, and gun control. Skin conductance is also used within risk analysis research. For example, when given a gambling card game task, it appears that, for successful performers, skin conductance levels (SCL) increase before selection of bad decks i.e. a risky choice (Crone, Somsen, Van Beek & Van Der Molen, 2004) which may suggest an internality associated with expertise. Such internality may also apply to experienced teachers who are likely to be skilled at concealing their emotions in class.

Outside the laboratory, Doberenz, Roth, Wollburg, Maslowski & Kim (2011) recorded the GSR of people over a 24-hour period and suggest the technology has become feasible for use outside the lab with some concerns, such as time delay and interpreting rapid response changes. The context of a mathematics classroom bears little similarity to experiments conducted in a lab, a point that has led to studies on the real-world applications of physiological data, including in education. For example, Koren (2016) developed a device to use with young children in school "to take measurements in children's most natural environment and where authentic behaviors are exhibited" (p. 14). Teachers are significant in forming emotional climates and deciding pedagogical approaches. In a university study about learning geography, student engagement during various pedagogical approaches, was measured using skin sensors on a subset of student participants (McNeal, Spry, Ritayan & Tipton, 2014). Unsurprisingly, they found movies and class dialogues to be more engaging than lectures.

The GSR version used

GSR measures small changes in skin humidity as one indicator of either stress or excitement in the body; an approximation to emotional intensity. The eSense ESensor® (Mindfield Biosystems Ltd, 2013), a simple affordable portable device which attaches to a mobile phone and according to the website, has been previously been used in studies on excitement, anxiety & stress. The sensor records bodily response, either positive or negative, and quickly produces data which is easily converted into an intensity graph. For practical purposes, despite differences in skin response activity being greatest on the palms or soles of the feet, and fingertip measurement (distal phalanges) not possible (a teacher needs to use their hands to write or gesture), researchers recommended using the intermediate phalanges on the first and second fingers of the non-dominant (usually left) hand (e.g. Crone et al., 2004), so the recording is less prone to interruption by loosening of the sensor fastenings or similar.

Whilst observing, I noted intensity points from the teacher, thus using the device to corroborate what I, as observer, experienced and felt. Researchers suggest there is delay between experiencing intensity and recording by the sensor of up to 10 seconds (Oxley et al., 2008) although other researchers suggest a shorter time. Using video recordings surrounding an episode of interest (the 2/3 minutes around the peak value) is crucial to provide corroborative data and raises the importance of subsequent teacher interpretation of the data, as only the teacher can suggest why or what stimulated any GSR change. I incorporated stimulated recall into my method as the final dimension of a holistic and temporal (before, during and after) design; forming a methodology based around case studies using interviews, observation and stimulated recall discussion. The post-observation discussions were designed to enable each teacher to talk about their thoughts and emotions during the videoed lesson, using the clips of their teaching as a prompt with discussion centred on an extract(s) of video. Only at the end of the interview sharing the resulting GSR graph and discussing interpretation of the graphical results.

The study's use of GSR sensor data: Carol and Debbie

By the time I was observing classes in school, much of the crucial (and intense) norm setting that takes place at the start of a new academic year was in place, so I observed normal daily practice rather than norm establishment. Participants were all teachers qualified (QTS) to teach mathematics

at secondary school level with a least 3 years' experience, thus limiting the influence of extremes of emotions associated with novice change processes.

The teachers wore the device in earlier sessions, without recording, until they felt comfortable, as wearing an ESensor device whilst teaching may unintentionally affect classroom interaction. I informally practiced with the device with lecturers in university seminars, and within a few minutes, wearers behave as normal and all the participants reported forgetting about the recording and, although aware of the device, there is no apparent change in their observable behaviour. Software for video editing (Microsoft moviemaker) was used to extract clips to share with teachers. The two episodes presented here were based on highest intensity readings. Observation notes enabled me to use the device to corroborate what I, as an observer, experienced. Occasionally, the ESensor device failed to work. Although I provided a belt pouch for phone and voice recorder, there were still trailing wires, which were occasionally pulled out. In order to conduct the post-observation discussions as soon after lessons as possible, preparing for discussion required rapid examination of the video, and the ESensor graphs proved particularly useful in the process of episode selection. The excitement and interest engendered by the use of the device was notable in all cases; it has novelty, even if it is occasionally unreliable. Participants were aware of, and were happy with, the risk that GSR measuring may reveal more than a teacher wishes to share, as what triggers emotional reactions can be deeply personal and is often hidden, even from self. Combined, the data of interview, video and ESensor recordings and post observation discussion tell one possible story of each teacher and their affective professional life. The physiological measure, through the use of the ESensor, results in numerical data, that, when graphed, provides a visual insight into a lesson to share with each teacher. I next present illustrations of the use of the ESensor with two participants, Carol and Debbie, showing one of the videoed lessons in each case.

CAROL

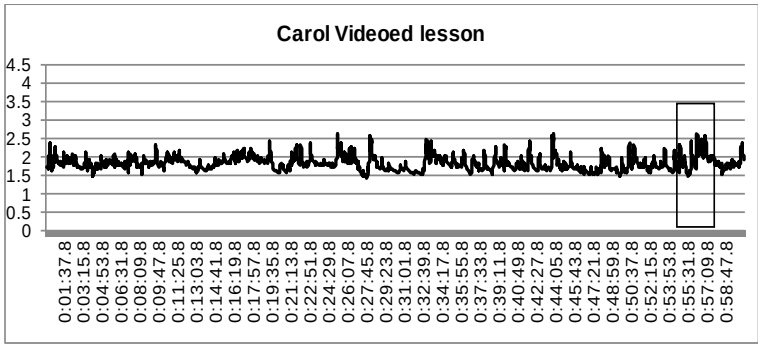

Figure 1: Graph of lesson (Carol)

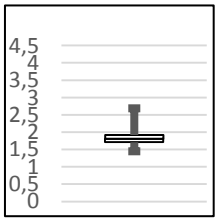

Figure 2: Teacher C (Carol) ESensor distribution

In the episode selected by the maximum reading in microSiemens (μS) over time (indicated by the box in Figure 1), Carol exhibits characteristics of mild frustration or puzzlement in a predominantly calm yet positive lesson. I do not think I would have noted this episode based on observation alone. In the episode Carol is modelling a careful assessment of the situation before acting, as well as patience and thoughtfulness when doing mathematics. She encouraged explanation from students with her head on one side, with expectant body posture and interested face (Figure 3). Finally, we have emotional uncertainty or doubt. This is visually expressed as biting her lip and putting her head on one side and then the other, and articulated later as apprehension, "... because I knew they

should be able to do it [Draw the graph], but they weren't giving me anything back". In post observation discussion, she assigns this doubt to either lack of understanding or to the group dynamic. Her behavioural response, both observed and subsequently explained, is to shift from instructional mode to conversational level. Accordingly, she sits down with the group. She explains this action as, "…trying to get down on their level and having more of a conversation".

Figure 3: Episode images (Carol)

One student in the group (shown to her left) is unknown to her, and she later expresses concern that she does not have a strong relationship with him. She thought that this unknown factor could potentially shift her out of her comfort zone and may account for the higher ESensor measurement. There were multiple possible reasons discussed in post-observation interview.

DEBBIE

The box in Figure 4 indicates the video clip used with Debbie. The higher values at the end occurred after the end of the lesson. Given the active nature of Debbie whilst teaching, with rapid movements and many emotional expressions, I would have predicted more variation in the graph (e.g. Figure 4), which are relatively consistent, although with a higher median value than for Carol (Figure 2, Figure 5) The base values for each teacher differ. This perhaps draws attention to the internal and external nature of emotions. For example, a teacher who is overtly emotional whilst teaching may have reduced internal affect or vice versa. Without the use of a physiological measure this potentially important difference is invisible.

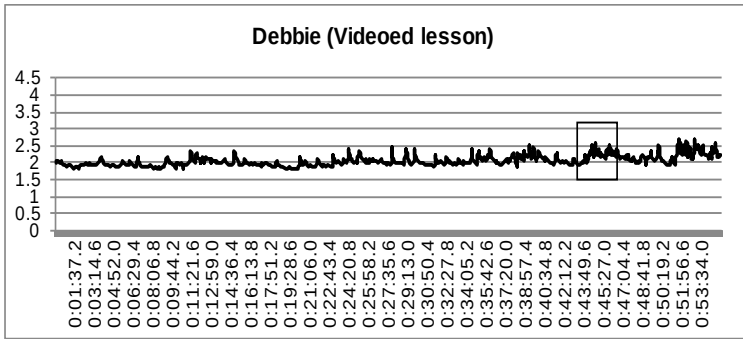

Figure 4: Graph of lesson (Debbie)

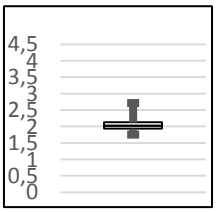

Figure 5: Teacher D (Debbie) ESensor distribution

In the selected episode, identified by uniting observation and ESensor, we see Debbie multitasking, moving rapidly from one group of students to another, answering and asking questions, a repeated pattern within the observed lessons. Even her discourse changes attention rapidly.

Student: Miss, we've done it!

Debbie: Wooo! [Excited voice] Can you please put it in your um...Right, you are going to take that and you're going to do that now...Put it in your paperclip and come and see me... so that's Kim and Lee, ok Lee. Right, take one of those, you are going to

> work on that between you...and stick it in... [To another student] Ooh...swearing? [Louder] No!

My impression from this is that modelling enjoying doing mathematics is important to her. For example, in the selected episode she uses playful language and body movements. She waves her arms to show an aeroplane flight path to two students who were engaged in an extension task on angles of elevation and depression. One of the considerations for ESensor use was movement, but comparing readings across the lesson, similar value appears without being associated with movement, a point verified by other studies (e.g. Koren, 2016).

Both teachers commented on their graphs in general at the end of the stimulated recall interview. Carol, whose graph is more variable, yet presents as mainly unemotional in the observed lessons, says of the video before seeing her graph, "I was shocked how calm I looked, I don't feel like I'm that calm… perhaps I am not conveying it [excitement], because a lot of it is the day to day of it, I've done it 20 times, 50 times, 100 times…" whereas Debbie, who is constantly active in her teaching, comments afterwards, "that's intriguing, maybe I look like I'm a bit mental but I'm actually pretty calm."

Discussion

The teachers were intrigued by emotional intensity research and I suggest the resulting discussions were focused and relevant. The exemplar teachers, despite no intention to compare, offer contrast in terms of visible emotions in the classroom. Debbie is overtly emotional as she teaches and Carol the opposite, yet their ESensor graphs appear to indicate otherwise, suggesting there is more to be learnt from the use of this tool. The use with Carol and Debbie, has challenged a common view that, in order to engage students in learning, there must be some notable teacher expression of positive emotions; that they have to be overtly expressed to be useful. However, this somewhat validates the use of the ESensor, as Carol is still experiencing emotions, albeit hidden, and her comments in interview confirm this. Both Carol and Debbie take pleasure in their classroom teaching, in having strong relationships and effectively communicating the mathematics that students need, as well as care for the student emotional needs (Lake, 2015). In this endeavour, emotions play a subtle, yet central, part within their different classroom practices. I would suggest that the use of the ESensor to hone in on their emotions in-the-moment, has strengthened attending to this aspect of the study.

A valuable contribution of the ESensor use is as director for the selection of episodes. The tool enabled a quick turnaround with creating a video extract to share with teachers (in all cases the next working day). Usually selection of stimulated video recall relies on repeated watching of lengthy video to select a suitable episode, and when selected inherently has bias through observer selection and interpretation. Some (although not all) bias is reduced by using the ESensor graph to select episodes. There are limitations to acknowledge; GSR offers a rough approximation of intensity, whilst the rapidity of change in emotions means interpreting the graphs can be challenging. This is one reason for attending to the teacher interpretation, but even then, there are many reasons for intensity at any point, some of which may not be shared with an interviewer. The most significant limitation is the multiple possible interpretations and hence the unreliability, unless intense emotions are involved. However, overall, a strength is in facilitating a more focussed discussion in

many cases, so more perhaps than affective gimmickry. A further limitation to acknowledge is that some lessons do not have notable indications of intense emotions. In these cases, the choice made was to use the maximum value, and to share the episode around this value with teachers. In some cases, the choice was little above the median for the lesson.

Three main implications arise from the use of the ESensor. Firstly, that awareness of use of emotions as a precursor to self-development has potential for developing self-regulation. Secondly, the data produced some potentially intriguing patterns for further investigation, albeit based on a small sample. Thirdly, as in both examples used here, the peaks frequently occurred in conjunction with supporting students to understand a specific point. This has implications for where a teacher should use intensity, something the experienced teachers may do instinctively and merits further investigation.

Consciousness of emotions, or even awareness of the activity of teaching is an issue especially pertinent to studying experienced teachers. New teachers are cognitively conscious, although not so effective at noticing wider than singular activity, such as when working one-to-one (Mason, 2002). Whilst experienced teachers often find it hard to articulate what happens when teaching, as only discrepancies are memorable. The use of the ESensor may support examination of engagement in contexts such as training. The second implication is that early indications imply that teachers who might be identified (by their students) as more engaging teachers are repositioning more frequently, which is associated with being responsive to students, but which is potentially more effortful. The ESensor may have a future role in identifying such patterns. One might speculate that it is this characteristic of engagement that the ESensor is helpful in identifying for early career teachers.

In the two examples, peaks occurred in conjunction with supporting students to understand a specific point. In Carol's case, how to create an appropriate graph, and for Debbie, what it means to visualise an elevation whilst managing other tasks simultaneously. One might suppose that both episodes require intensity to communicate the ideas, and as such is effortful, as highlighted by the ESensor. Teachers direct their communicative effort and intensity towards points of most impact on learning, meaning to change pace, to interrupt as in performance, or to restore emotional balance. Yet teachers cannot continually sustain high intensity, so there is much to be learnt about deliberate and instinctive placing of intensity. The idea of managing emotions of others through meta-awareness of intensity is not new. Mason (1989) talks of meta-awareness in terms of 'Knowing-to', which is, "…the kind of knowledge which enables people to act freshly and creatively" (p245). Amongst the participants, I observed apparently unconscious and almost instinctively managed tailoring of intensity. The use of the ESensor was aimed at partially addressing this methodological challenge, as assessing the degree of emotional regulation is important to interpreting emotions of classroom teachers.

To conclude, there are indications that the incorporation of physiological data is a powerful addition to common methodology for examining emotions in-the-moment. The use and sharing of each resultant graph, by acting as a focus for discussion, has facilitated discussion between myself and the participant teacher, and enabled each teacher to explore their emotions during the selected episode, and to articulate these through the medium of the ESensor. The use of the ESensor seems

to have focused attention on what may be critical moments in a lesson. The potential is rich, the study is encouraging of the potential for GSR use in future research, both to validate the use of a sensor as having value within affect research and as a means to address the concern of affect researchers around the unavailability of emotions and hence one known limitation in any study of emotions. The ESensor usefully guided the selection of extracts from a lesson, focussing attention on indications of intensity, in addition to observation notes and my own response to the teacher.

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