Emotions and problem solving by prospective primary school teachers

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This paper reports on a study into the motivations and emotions of prospective primary school teachers and how they change before, during and after a problem solving task. The results highlight the need to build the emotional intelligence or cognitive-affective competences, resources and strategies to overcome negative emotion and to scaffold learning.

Keywords: motivation; emotion; problem solving

Background

The link between emotion and the experience of learning mathematics has long been recognised (Buxton, 1981). In particular, negative experiences, leading to negative emotions, are seen to inhibit or disable the learning of mathematics. Buxton's study provided evidence of the damaging effect of lack of confidence and competence that motivation and emotion play in the learning of mathematics. Skemp (1977) also described the part played by a range of emotions in successful and unsuccessful strategies for learning mathematics. Yet until recently, much research on emotion and mathematics has focussed on anxiety, and particularly test anxiety (Hembree, 1990). Evans (2000, p. 108) claimed "there is still little or no explicit acknowledgement of the importance of the affective – feelings of anxiety, frustration, pleasure and/or satisfaction which attend the learning of mathematics." More recently, there have been attempts to classify emotions related to learning mathematics (Pekrun, Frenzel, Goetz, & Perry, 2007). This characterisation does not account fully for the wide range of emotions reported in other research (Schorr & Goldin, 2008). Schutz and DeCuir (2010) point out the tendency of research to characterise emotion as trait, and that this in turn tends to promote more reductionist interpretations. They note the methodological problems in the attempt to study emotions, since they happen 'in vivo', and in the moment. Although not specific to mathematics, Meyer and Turner's (2010) review of emotions in classroom motivation research argues for the key role of emotions in learning, using terms such as 'essential' and 'pivotal'.

In relation to emotion and disaffection with school mathematics, there have been few studies. One such is Skinner, Furrer, Marchand and Kindermann. They view disaffection as negative engagement, or, more specifically (2008, p. 767): "the occurrence of behaviours and emotions that reflect maladaptive emotional states." Amongst the emotions accounted for are boredom, anxiety, anger and shame. The framework takes account of these emotions, but offers no theoretical account of their genesis. Lewis (2016), using a Reversal Theory structure, has attempted to widen the range of emotions studied, and has reported on the existence of a range of negative emotions that inhibit or disable learning.

Emotions, then, have received less attention than other affective constructs. In particular, emotion-as-state has been under-researched. The importance of state, as opposed to trait, or to more stable, cognitively-mediated constructs such as attitudes and beliefs, has been pointed out by Hannula. He

says (2012, p. 155): “There is a clear imbalance in favour of studies that focus on traits over studies that focus on states.”. He goes on to say (ibidem, p. 155): “In particular, studies that focus on the dynamics of emotional or motivational states in classroom or other learning community are still rare.”

More recently, researchers have begun to pay attention to this deficit. The Cerme community, at Cerme 9, 2015, saw a number of papers address issues of emotion, and focussed on emotion-as-state, in rather innovative ways. Liljedhal (2015) collected data from 38 prospective mathematics teachers after an intensely negative experience. The results contribute to work in mathematics education that anchors emotions in a theoretical framework and links them to other constructs in the affective domain, particularly motives. Di Martino and colleagues (Antognazza, Di Martino, Pellandini, & Sbaragli, 2015) look at if, and how, young students’ emotions change during problem solving, the factors behind the change, and the potential impact of certain emotional changes on mathematical activity. They investigate young students’ problem-solving difficulties, and the links between affective and cognitive factors in context. They note that intrinsic causes seem to be attributed by students to positive emotions, and extrinsic causes to negative emotions.

Despite there being a number of significant differences between the studies, they share a number of features that help to address the difficulties of studying emotion ‘in-situ’. They both involve polling participants before, during and after the performance of mathematical tasks, and both make creative use of open-ended responses. These studies can be taken together to form a conversation within the research community, where researchers respond to identified gaps in the field, and cooperate to move the research on at each stage. A number of points seem to me to be particularly worth exploring further. The first is the interaction between affect and cognition, which research is only now beginning to explore. Secondly, as pointed out above, we need to understand more fully how affective and emotional states help to facilitate or inhibit learning. Further evidence is needed of the dynamic progression of motivational and emotional states through the problem solving process, how these interact with cognition and cognitively-mediated constructs such as attitudes and beliefs.

The study

The aim of the study, then, is to investigate the motivations and emotions associated with the performance of a problem solving task. More specifically:

What are the motivational and emotional pre-dispositions of prospective primary teachers to performing a problem solving task? How do these change during the process of the task, and how are they interpreted after completion of the task? What is the role of self-regulatory skills in mediating negative emotions? How do motivations and emotions interact with cognition in the undertaking of the task?

Prospective primary school teachers on initial teacher training represent a category of whom many members are lacking in confidence and a facility in mathematics (See Liljedahl, 2015). There is a lot of interest in this group for this reason. Looking to take and adapt the methods and protocols from the studies outlined above, I ran a session with a group of primary PGCE students in which these ideas can be explored. The protocol involves presenting them with mathematics problems, and

polling them both prior to working on them and after the task, about their affective dispositions. The task was actually a set of graduated questions involving working out terms in series in which they were given the first few terms. By using a graduated set of tasks, I was hoping that there were tasks that were simple enough for everyone to get some right, but also some that would stretch the most accomplished.

Seventeen students on the Postgraduate Certification of Education (PGCE) programme for prospective primary school teachers at a UK University volunteered to attend a lunchtime session. They were informed only that I was interested in researching affect in mathematics education. All but two of the volunteers were women, and they were split equally between those who considered being mathematics specialists, and those who did not.

At the beginning of the session, students were briefly shown the task, and then given a questionnaire. Prior to the task, they were asked to rate the difficulty of the task on a 5-point scale from easy to difficult. They were also asked how they felt about the task, what they were thinking, and why. They then undertook the written task. After completion of the task, they were asked how well they did on the task, to describe their emotions and thoughts and feelings as they undertook the task, and about their most negative emotion, and how they dealt with it. The data was content analysed according to the categories of responses, as reported below.

Results

Initial thoughts and feelings

Ten respondents assessed the task as quite easy, and no one assessed it as difficult. Consistent with the Antognazza et al. study, students who rated the task easy or quite easy felt positively about the prospect of doing the task. When asked how they felt about the prospect of the task, prior to undertaking it, a range of positive feelings were expressed:

I like a challenge; Excited; Confident; Relaxed; Curious; Anticipation

These all reinforced the apparent perceived simplicity of the task. However, there were a few other responses (and these all came from volunteers who rated the task as of medium difficulty):

> It makes me feel excited because I want to get it correct, but scared because I might get it wrong (sc)
>
> I think I will be able to do the first ones and then they will get harder and I probably won't be able to do them so anticipation (ja)

When asked what they were thinking, and why, most volunteers reflected confidence and excitement. The two exceptions were those again, who judged the task to be of medium difficulty.

> How can I get it right and not look silly. (sc)
>
> I'm thinking that although maths isn't my strongest subject, I'm not being judged and marked so I feel more relaxed (an)

In terms of the task itself, volunteer scores were evenly distributed between scores of 4, 5 and 6 out of 6, reflecting their evaluation of the task as fairly easy. After the task, volunteers were asked how

well they thought they did, and most seemed to judge that they did quite well. What is clear from the narratives is that the motivation to succeed at the tasks was strong. There are multiple mentions of determination and perseverance.

I really wanted to get the answer …… I didn't want to be defeated (ce)

My main emotion was one of determination (rp)

I was just determined to get the right answer (cp)

Added to this, not only is getting right answers important, but speed in doing so is also seen as a requirement. Thus we hear:

How quickly I could work it out.. (cp)

I wanted to get through it quickly (sj)

I was quite upset when I took a little bit longer to do the last one (id)

Fine until I felt rushed due to time (cw)

A number of responses suggests that getting ANY answer wrong is unacceptable, and causes negative emotion.

I didn't do well because I was unable to answer the last two questions (an)

Post task reflection

Although the questionnaire prompts participants to distinguish between emotions on the one hand, and thoughts and feelings on the other, including how they dealt with their most negative emotion, the responses seem to represent a 'package deal' in which the emotions and cognitions are conflated, thus demonstrating how intimately connected they are. In terms of emotions, a range of words and terms are used. They include: confidence; stress; panic; confused; happy; confident; uncertainty; worried; feeling worse; frustration; anger; annoyed; irritated.

This list seems to indicate quite a narrow range of primary emotions, comprising variations of anxiety and anger, on the negative side, and happiness and confidence on the positive side. Confusion and uncertainty appear to be cognitive conditions with negative valence, that result in negative emotions such as anxiety.

Again, as with Antognazza et al., making progress and getting right answers are seen as a vital condition of satisfaction.

I was just determined to get the right answer, each time I solved one I was happy (cp)

Mainly joy at being able to do the task relatively easy (gh)

The sense of satisfaction and positive emotion continues until the prospect of getting the answer right is perceived to be at risk, when the emotion turns negative. Getting answers right, and then not being able to get an answer, is expressed in emotional dualities:

Happiness, success, proud I could do it. Annoyed when I had to take a few looks at the last one (id)

The negative feelings seem to easily initiate more deep seated negative and disabling thoughts:

> I felt quite happy and relaxed at the beginning when I was able to complete the sequences but later on I felt inadequate as everyone else seemed to know the answers (an)
>
> I began to doubt myself (nd)
>
> Frustration stimulating a negative thought process that I am not that great at maths (ao)
>
> I was happy and confident until I reached 'E'. At this point my uncertainty about maths re-surfaced. I have never been confident in maths and so the fact that I struggled on the last 2 questions made this emotion re-surface (nd)

Other categories of narrative expression also emerge from the data. One category relates to the mathematical or heuristic strategies employed by the volunteers either in the search for pattern or answers, or in response to negative emotional conditions. Examples include:

> My prior knowledge of sequences helped (cs)
>
> My confidence went up and down as I used trial and error, once I'd figured out the pattern that was fine (cp)
>
> Try out a variety of methods until I found the one that worked (id)
>
> My most negative emotion was before the last question when I worried 'whoa' not sure I can do this, but I dealt with it by trying to think about the problem from a different perspective and take a different approach as I had with other questions (ce)
>
> I approached it very methodically, wrote things down to help remember what I was processing mentally. As I cracked each pattern I felt more willing to try the next (rp)
>
> I was thinking about the possibilities of how to work each one out. What different methods may I need to use? (hr)

Since the tone of emotion changed from pre-task to post-task, and from mainly positive to mainly negative, it is interesting to examine how these students deal with the negative emotion. There is evidence here of significant self regulation, which is often mediated by self-talk:

> Can I do it? Can't I do it? (sj)
>
> I had to tell myself that I had tried my best (nd)
>
> Come on you can do better (cp)
>
> It's not a test so it is ok if and when I get it wrong (ja)

Self talk also plays a part in the negative case:

> I couldn't find the sequence and therefore must be rubbish at maths (sc)

The following example illustrates such a negative **pathway** or series of responses:

> I was confused as soon as I couldn't find an obvious pattern and consequently panicked and guessed. That made me feel inadequate (sc)

Note the sequence (with comments in parentheses):

1. I couldn't find an obvious pattern… [searching for pattern is a cognitive strategy – in this case unsuccessful]
2. This made me confused…[lack of success leads to lack of solution and the cognitive condition leads to high arousal]
3. Therefore I panic…[this induces negative emotion]
4. When I panic I guess…[this leads to a poor behavioural response]

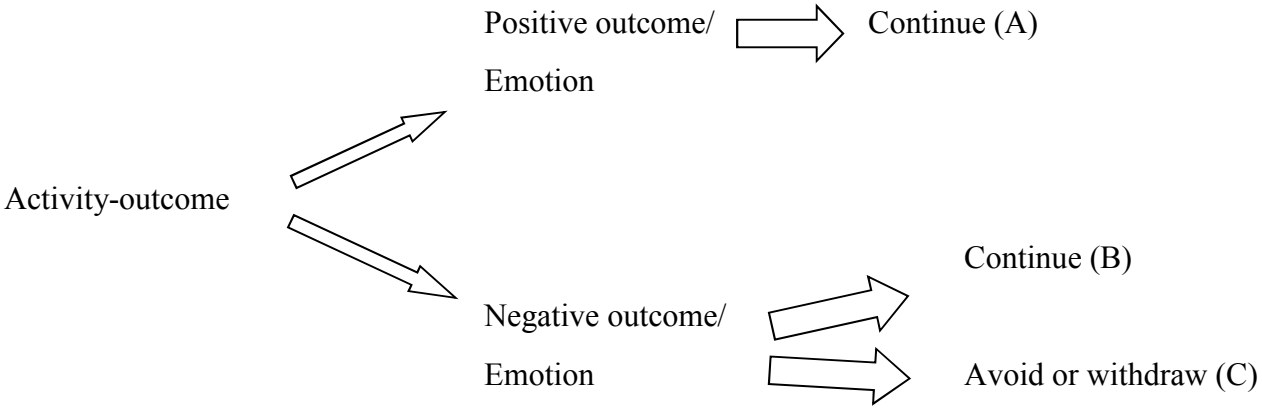
Many of the accounts talk about confusion leading to panic, and the panic relates to the very strong (but unsatisfied) need for progress, often leading to inappropriate strategies for quick solutions:

I felt panicked to try and find a solution as quickly as possible (sc)

Motivational and emotional pathways in mathematical problem solving

By assembling the evidence, it is now possible to propose a model for the possibility space of the pathways for this motivational-emotional-behavioural nexus. To do this, I will draw on the reversal theory framework, but instantiated by data from this study, and consistent with data from other, similar studies. More details about the eight motivational states, and their associated emotions can be found in Lewis (2016).

The motivational state combination determines how the experience or engagement in the task will be evaluated against the needs of the active states. If the need is satisfied, or if satisfaction is anticipated, it will lead to positive emotion. If not, it will lead to a feeling of frustration, and negative emotion determined by the specific state combinations active at the time. In this case, there is a behavioural dilemma which can be resolved in two ways. Illustrated visually, the space comprises the following pathways:



In the serious self-mastery state combination, which evidence suggests is the dominant motivational disposition of students in problem solving contexts, achieving progress, getting right answers (quickly) and the associated feeling of power or competence, is necessary for a positive affective outcome. The likely behavioural response is attraction, leading to the desire to continue (A).

If progress or positive outcome is not achieved in the serious self-mastery motivational disposition, this will result in anxiety, anger (serious), or humiliation or helplessness (self-mastery, losing),

whereas in paratelic (playful) state combinations, boredom or sullenness will result if arousal is low and excitement is unavailable.

From this situation, the student has choices available. One choice is to use strategies to override or mitigate the negative emotions. One such approach is the learnt behavioural response to 'call down' mathematical strategies or heuristics, as evidenced above. Another available resource is the application of metacognitive skills such as determination or perseverance. This allows the student to continue, even if it is painful or uncomfortable to do so.

There is also another process that appears to take place. Negative emotions such as anxiety, anger, (possibly in conjunction with helplessness or humiliation) seem to induce a strong need for meaning, significance or explanation for the failure. Since this is unavailable in the situation, it appears to initiate a search of cognitively-mediated constructs (such as attitudes or beliefs) in order to satisfy this need. This search for meaning seems to be strongly mediated by self-talk, and may result, as the evidence shows, in evaluations of self and capability ('You can do it' or, 'I am dumb'), or evaluations or attributions related to the situation ('these questions are too hard', 'mathematics is useless'). But as Antognazza et al. point out, negative emotion is more often associated with explanations extrinsic to the problem at hand.

If such evaluations about self or the situation are positive and enabling, they provide a kind of behavioural override to the negative emotion, and encourage further qualified or reluctant attraction and engagement, as expressed, for instance, in 'come on, you can do better', as illustrated in path (B). If, on the other hand, such evaluations are negative, they result in repulsion and avoidance or withdrawal from the task, as in path (C). We can see this last option in operation in statements of the form 'I am no good at maths', 'I feel less intelligent than the others.'

Since all students will, at times, encounter negative emotions, it is important to understand in more depth what influences the choice between pathways B) and C). It seems clear that having a range of cognitive-affective resources are the key to the likelihood of students choosing pathway C). The evidence here suggests that these resources and strategies fall into three categories:

- A repertoire of mathematical or heuristic processes to enact in seeking progress in tasks and problems.
- Meta-cognitive and self-regulatory resources such as determination and perseverance in order to continue with a task when it is affectively uncomfortable or painful to do so.
- An architecture of positive or enabling cognitively-mediated structures or representations such as attitudes or beliefs, that provide a frame of confidence in which otherwise psychologically risky situations can be tackled.

Discussion

This study, then, has attempted to contribute to the understanding of affect, and particularly negative emotions and their effect on learning or not learning, mathematics. A number of interesting points arise. Firstly, further evidence to the Liljedahl study of just how prevalent negative emotion is among prospective primary teachers. Secondly, the evidence here shows just how intimately

connected affect and cognition are in undertaking mathematical tasks, and the influence of affect on learning, or not learning mathematics, and indeed, the reciprocal influence of learning on affect. I have proposed a model of the mechanisms by which emotion and cognition interact when students are engaged in mathematical tasks, and in particular, ways that aspects of cognition and behaviour can be used to mitigate negative emotion, such that it doesn't disable learning.

This is a modest study which has a number of limitations, especially related to the small sample, and the fact that they were volunteers. Because of this, no attempt has been made to make quantitative generalisations from the data.

One of the key points to emerge that should inform teaching practice and pedagogy is that explicit focus and attention is needed to help students to build the emotional intelligence or cognitive-affective competences, resources and strategies to overcome negative emotion and to scaffold learning.

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