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Children's emotions in math problem solving situations: Contributions of self-concept, metacognitive experiences, and performance

Elise Tornare [a, *], Nikolai O. Czajkowski [a, b], Francisco Pons [a]

[a] Department of Psychology, University of Oslo, Box 1094 Blindern, 0317 Oslo, Norway
[b] Department of Mental Health, Norwegian Institute of Public Health, Nydalen N-0403, Oslo, Norway

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ABSTRACT

This study examined 1) experiences of six discrete emotions – joy, pride, contentment, worry, shame, hopelessness – after solving a math problem of students aged 10–12 years, and 2) the contribution of self-concept, metacognitive experiences (feeling of difficulty and feeling of success) and performance on emotions experienced after the task, controlling for gender and emotions experienced before the task. Results indicated a decrease in joy and contentment after problem solving. Performance did not contribute to emotions apart from hopelessness. The influence of performance on hopelessness was mediatized by metacognitive experiences. Self-concept contributed to joy, pride and shame but its influence became non-significant when we controlled for metacognitive experiences. Feeling of success mediatized the effect of self-concept on joy, pride and shame. Metacognitive experiences were also found to be important predictors of all emotions except worry. The need for new paradigms to study emotions in education is discussed.

1. Introduction

In the past two decades, research on emotion in learning has begun to flourish (e.g. Pekrun, Goetz, Titz, & Perry, 2002; Pons, Hancock, Lafortune & Doudin, 2005; Linnenbrink, 2006). As underlined by Schutz and Lanehart (2002) in their introduction to a special issue of the *Educational Psychologist* on emotion and education "emotions are intimately involved in virtually every aspect of the teaching and learning process and, therefore, an understanding of the nature of emotions within the school context is essential" (p. 67). Research on the role of emotion in education showed a relation between emotion and different aspect of learning such as the use of metacognitive strategies, metacognitive experiences, motivation, goals and achievement (e.g. Efklides & Petkaki, 2005; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Pons, de Rosnay, & Cuisinier, 2010; Schutz & Pekrun, 2007 for illustrations and reviews). These studies represent a significant advance. However, little is known today about the origins of the emotional experiences of primary school children involved in a problem solving task.

If we consider emotion as a situated and dynamic process (Efklides & Volet, 2005) it seems that an understanding of the nature of emotion within the school context requires a situated examination of emotions and of their sources. To date, however, research on the determinants of student's emotional experiences in learning have mainly focused on trait-like measures of individual variables such as self-concept, control beliefs, motivation, goals and trait-like measures of emotions, or on affect categorized in terms of valence. Moreover, research on emotions experienced in problem solving situations has largely been conducted on secondary school pupils and the modest research on primary school pupils has focused almost exclusively on anxiety (Lichtenfeld, Pekrun, Stupnisky, Reiss, & Murayama, 2012; Pekrun et al., 2002). The present study examined six discrete emotions experienced by primary school children after solving math problems and the respective contribution of self-concept (a trait-like variable), metacognitive experiences of difficulty and success, (both subjective and situated variables and actual performance (an objective and situated variable) to their emotions. We believe it is essential to

* Corresponding author.
E-mail address: elise.tornare@psykologi.uio.no (E. Tornare).

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draw attention on children's emotional experiences in learning for, 1) an understanding of the relation between children's developing mastery of school tasks, as well as their developing self-perception and emotions may have important implications on theorizing and, 2) such an investigation is necessary to guide educational practices. Moreover, given the various underlying phenomenology of emotions, we believe a focus on discrete emotions is necessary in the examination of their sources. Indeed, a focus on emotion characterized in terms of valence would not allow for a nuanced investigation of their sources (for a reflexion on this issue see Linnenbrink-Garcia & Barger, 2014).

2. Prior research

2.1. State emotion experiences related to problem solving

The question of the variations in emotional experiences in the context of school problem solving has been explored through qualitative and quantitative approaches. In a qualitative study, Op't Eynde and Hannula (2006) examined, in reference to the theoretical model of Scherer, Schorr, and Johnstone (2001) fluctuations in the emotional experience of a student while he solved a mathematical problem. This case study revealed substantial fluctuations in the emotional experience of the student going from happiness, to worry, to relief, to frustration/anger, to nervousness and pride. These fluctuations were interpreted by the authors as the expression of the student on-going appraisals of the situation. The design and self-report measures of emotional experiences used in quantitative studies (Cuisinier, Sanguin-Bruckert, Bruckert, & Clavel, 2010; Efklides & Petkaki, 2005) did not allow to grasp fluctuations as delicately. However, results from Cuisinier, Clavel, de Rosnay, and Pons (2010) investigating the impact of the emotional content of text used in a dictation task indicated that the intensity of pleasant emotions experienced by students (aged 10–11 years) decreased while working on the task and increased once the task was over, whereas children reported experiencing unpleasant emotions with more intensity while they performed the task.

2.2. Relations between self-concept and emotion

Bandura's theory of perceived self-efficacy (1982, 1989, 1993) holds that the evaluation individuals make of their competence in a specific domain elicits emotions. It posits self-efficacy as positively linked to pleasant emotions and negatively related to unpleasant emotions. Recently Boekaerts (2007) found that competence judgments (self-efficacy beliefs) of junior high school students were indeed positively linked to pleasant affect and negatively linked to unpleasant affect experienced in mathematics homework sessions. However, the relation was significantly stronger for pleasant affect compared to unpleasant affect ($r = .42$ and $r = -.14$ respectively). Low self-efficacy beliefs were also found to contribute to the experience of shame in school settings (Turner & Schallert, 2001). In a dynamic perspective, self-efficacy theory also specifies the relation between emotions and perceived self-efficacy is bidirectional.

In line with these results, recent empirical findings from Pekrun et al. (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010; 2011) showed that trait-like experiences of enjoyment, hope, pride, relief, anger, anxiety, shame, hopelessness, boredom were mediated by trait-like control appraisals which refers to the beliefs students hold about their competence, their expectancies and attributions of success and failure (see Pekrun's 1992, 2006 for a description of the control-value theory). Through the same theoretical framework, Lichtenfeld et al. (2012) investigated children's (from 7 to 12 years old) experience of enjoyment, boredom and anxiety related to mathematics. Their results, in line with Pekrun et al.'s (2010, 2011) findings on college students suggested perceived control was positively related to enjoyment and negatively related to anxiety and boredom.

As underlined by Goetz, Cronjaeger, Frenzel, Lüdtke, and Hall (2010) self-efficacy, control beliefs and self-concept are related constructs (see also Bong & Skaalvik, 2003; Bouffard & Vezeau, 2010) and can be expected to show similar relations with emotional experiences. In line with this assumption, the abundant research on anxiety experienced in mathematics learning has contributed to determine self-appraisals such as self-concept, self-confidence, self-efficacy and expectancies related to mathematics as important sources of this experience. These self-appraisals along with the associated experienced anxiety also seem to mediate the quality and development of mathematics learning (for a review see Malmivuori, 2001). Moreover, results from Goetz et al. (2010) revealed that self-concept was positively related to enjoyment and pride and negatively related to anxiety, anger and boredom. The strength of the relation was moderated by academic domains, age and type of emotions. Correlations between self-concept and emotional experiences were stronger for the quantitative domains (mathematics and physics) compared to the language domains (English and German); for students in grade 11 compared to grade 8; the experience of pride showed a stronger relation with self-concept than anxiety, anger and enjoyment; boredom showed a weaker relation with self-concept. Results yielded by these studies brought evidence of substantial relations of self-concept with trait like emotions. However, research on the contribution of self-concept in the elicitation of emotions experienced in a problem solving situation are still scarce.

2.3. Relation between metacognitive experiences and emotions

Following Efklides (2001, 2006, 2011), we refer to students' task-specific appraisals of learning situations such as their perception of the difficulty and of their success in completing the task as *metacognitive experiences* (e.g. Georghiades, 2004 for a review). Based on Flavell (1979) theoretical framework of metacognition, Efklides (2006) definition posits that "metacognitive experiences are influenced by person, task and context characteristics and, despite their interrelations, each of them conveys different information about features of cognitive processing. Thus they form the interface between the task and the person, and inform the person on his/her progress on task processing and the outcome produced."(p. 7). Metacognitive experiences can take the form of metacognitive feelings such as feeling of difficulty and other aspects of cognitive processing (Efklides, 2001). The metacognitive experience of difficulty or feeling of difficulty (Efklides, 2001) arises during the processing of tasks that require "careful and highly conscious thinking" (Flavell, 1979, p. 908), when a lack of fluency, interruptions (obstacles) and conflict in responses are experienced (Efklides, 2002, 2006; Lafortune & Pons, 2005). Difficulty may be experienced at any moment before, during and after task processing and the intensity of these experiences are likely to vary throughout the process of problem solving (Efklides, 2002, 2006). Feeling of difficulty also triggers control decisions, such as effort investment and strategy use (Efklides, Samara, & Petropoulou, 1999), and influences causal attribution (Metallidou & Efklides, 2001). The metacognitive experience of success, or feeling of success also involved in problem solving, relates to the quality of the solution produced (correct/incorrect). It may be viewed as a subjective counterpart of the objective measure of performance. In a study examining the effects of induced mood (positive and negative) on metacognitive experiences of children in their last year of primary school, Efklides and Petkaki (2005) found that negative mood experienced at the