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The power of emotions: Can enjoyment and boredom explain the impact of individual preconditions and teaching methods on interest and performance in mathematics?

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ABSTRACT

We investigated students' emotions as intervening variables between teaching methods, motivational and performance prerequisites, and outcomes. 144 students from German schools were assigned to two conditions. In one condition, students were prompted to develop multiple solutions for modelling problems that were missing information. In the other condition, students had to find one solution for modelling problems that were not missing information. Students' interest and performance were measured before and after the 5-lesson teaching unit, and students' enjoyment and boredom were measured during the teaching unit. The path analyses revealed: (1) Students who developed more solutions enjoyed their mathematics lessons more and were less bored than students in the other condition; (2) Enjoyment affected students' interest and performance at posttest and mediated the effects of prompting them to find multiple solutions on interest at posttest; (3) Students' enjoyment during learning mediated the effects of prior interest on interest at posttest.

1. Introduction

Emotions are important for students' learning of mathematics (Goldin, 2014; Zan, Brown, Evans, & Hannula, 2006). In recent decades, a control-value theory of achievement-related emotions was proposed (Pekrun, 2006), and research confirmed that perceived control and the value of learning activities were antecedents of achievement emotions (Buff, 2014; Pekrun, Cusack, Murayama, Elliot, & Thomas, 2014). However, more research on the connections between emotional, motivational, and cognitive variables in mathematics education is needed with regard to the following issues: the predictors of emotions in the classroom, the influence of classroom emotions on students' motivation and achievement, and most importantly, the teaching methods that positively influence students' emotions (see overview by Pekrun & Linnenbrink-Garcia, 2014). In this study, we aimed to connect two research fields: the psychology of emotions and learning. Further, because students' performance and interest are both considered to be important for learning mathematics (Schukajlow & Krug, 2014a; Zan et al., 2006), we sought to contribute to the improvement of the practices applied in schools by examining the effectiveness of a teaching method for cognitive and motivational outcomes.

We assessed emotions during a teaching unit that aimed to promote students' interest in mathematics and their ability to solve modelling problems. Modelling problems are demanding tasks that are connected to reality, and the ability to solve these problems is important for students' current and future lives (Niss, Blum, & Galbraith, 2007). In the current study, we proposed and tested a theoretical model in which a teaching method that prompts students to find multiple solutions, the number of solutions developed, students' prior interest, and students' prior performance affected emotions in the classroom, which then influenced their interest and performance.

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2. Prior research, theoretical model, and hypotheses

2.1. Enjoyment, boredom, interest, and performance: what do we know about their relations?

2.1.1. Enjoyment and boredom as achievement emotions

Emotions are defined as complex phenomena that include affective, cognitive, physiological, motivational, and expressive parts (Pekrun & Linnenbrink-Garcia, 2014). Enjoyment and boredom are important for human life as they are connected to career aspirations and career choice (Wigfield, Battle, Keller, & Eccles, 2002) and were identified as the second and third most prevalent reasons for not continuing with mathematics after graduation from secondary school (Brown, Brown, & Bibby, 2008). We conceptualized enjoyment and boredom in a domain-specific manner and assessed these emotions while students were engaged in task processing because task processing was found to be one of the main activities in mathematics classrooms (Hiebert et al., 2003). While enjoyment was conceptualized as "having fun," the focus of boredom was on having trouble remaining alert and continuing to work.

In the control-value theory of achievement emotions, appraisals of the value and control of learning activities and outcomes are assumed to be important for activating achievement-related emotions (Pekrun, 2006). In the context of non-routine problem solving, students with high appraisals of control and who value of their activities can be expected to enjoy learning and not be bored during learning activities. Positive changes in perceived control and value were found to lead to positive changes in school students' enjoyment of mathematics and college students' boredom (Buff, 2014; Goetz, Pekrun, Hall, & Haag, 2006).

2.1.2. Enjoyment, boredom, and interest

Interest represents a specific person-object relation and is characterized by a person engaging and reengaging with this object over time (Hidi & Renninger, 2006; Krapp, 2005). A positive relation between interest-related measures and enjoyment was found by students at school and at university (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Tulis & Ainley, 2011). The expectation that "… personal interest in the activity domain can give rise to appraisals of controllability and value – promoting students positive emotions, such as enjoyment of learning" (Ainley & Hidi, 2014, p. 217), among other effects, was confirmed in studies in the context of self-regulation, where effects of motivational beliefs, including interest, were found on positive emotions (Ahmed, van der Werf, Minnaert, & Kuyper, 2010; Winberg, Hellgren, & Palm, 2014). Hence, prior interest should have a positive effect on enjoyment. However, a lack of interest in combination with a requirement to solve problems during regular mathematics classes can trigger anger, anxiety, or other negative emotions but not obviously boredom (Pekrun, Hall, Goetz, & Perry, 2014). To our knowledge, the effects of prior interest on students' boredom have not yet been tested. On the basis of prior research, we expected that students' prior interest would predict enjoyment, whereas the effect of a lack of prior interest on boredom could not clearly be derived from prior research and was based on theoretical assumptions from the control-value theory of achievement emotions (Hypothesis 1).

Emotions during learning might not only predict interest-related measures but may also be influenced by them. Positive affective experiences, including enjoyment, during learning accompany situational interest and are important for triggering students' individual interest (Ainley, 2007; Krapp, 2006). Moreover, students' positive affective experiences predicted motivation in a longitudinal study in mathematics over one year (Buff, Reusser, Rakoczy, & Pauli, 2011) and supported the expectation of positive effects of enjoyment on interest (Hypothesis 2). The relation between boredom and interest-related measures is not yet clear. Most studies have found a negative correlation between boredom and interest (Pekrun, Hall, et al., 2014; Vogel-Walcutt, Fiorella, Carper, & Schatz, 2012). These results suggest negative effects of boredom on interest (Hypothesis 2). However, the effect sizes of correlations between boredom and interest-related measures were lower than correlations between enjoyment and interest-related variables (correlation of 0.45 between enjoyment and intrinsic motivation and correlation of −0.23 between boredom and intrinsic motivation by Pekrun et al., 2011). One possible explanation for these weak relations may be that the learning process of highly interested students can be accompanied not only by positive but sometimes also by negative emotions (Ainley & Hidi, 2014).

As prior interest should affect enjoyment and boredom, and as enjoyment and boredom should influence interest at posttest, we expected prior interest to have an indirect effect on interest at posttest with emotions as intervening variables (Hypothesis 3).

2.1.3. Enjoyment, boredom, and students' performance

Students' prior achievements can predict students' control and value beliefs, and via these appraisals, their enjoyment and boredom as well (Pekrun, 2006). Empirical evidence for the potential effects of prior performance on enjoyment can be found in the correlations between students' grades in mathematics at the beginning of the school year (fall, T1) and enjoyment or boredom measured during the school year (winter, T2; spring, T3) (Ahmed, van der Werf, Kuyper, & Minnaert, 2013). Further evidence comes from positive correlations between students' mathematical performance in grades 3 and 6 and enjoyment in grades 6 and 9, respectively (Hannula, Bofah, Tuohilampi, & Metsämuuronen, 2014). School students' boredom was not related to grades (Ahmed et al., 2013), but college students' boredom was predicted by prior grades in three of four estimated regressions in a study by Pekrun, Cusack, et al. (2014) and Pekrun, Hall, et al. (2014). On the basis of these findings, we expected positive effects of prior performance on enjoyment (Hypothesis 1). As no effects of prior achievements were found at school and partially found at university, we considered theory and expected a negative influence of prior performance on boredom (Hypothesis 1).

Not only can the impact of performance and interest on emotions be assumed but also the opposite direction. Students' enjoyment is positively related to grades at school and university (0.22 and 0.46, respectively, Goetz, Frenzel, Pekrun, Hall, & Lüdtke, 2007; Pekrun et al., 2011), and positive changes in enjoyment produce positive changes in students' grades (Ahmed et al., 2013). The relation between enjoyment and performance assessed by competence tests has been investigated less often and has ranged from 0.15 to 0.45, depending on the type of questionnaire and the kinds of problems used to measure performance (Schukajlow & Krug, 2014a). An analysis of the reciprocal effects of enjoyment and students' performance in primary and early secondary school, however, did not confirm that mathematics performance could be predicted by students' enjoyment (Hannula et al., 2014). Because of the positive correlation between enjoyment and achievement (Schukajlow & Krug, 2014a; Goetz et al., 2007) and the positive effects of students' enjoyment on students' grades (Ahmed et al., 2013; Mega, Ronconi, & De Beni, 2014), we expected that enjoyment would positively influence students' performance (Hypothesis 2). A pattern similar to enjoyment has also been revealed for the effect of boredom on student achievement. College students' boredom was negatively correlated with their grades (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010), and school students' boredom was negatively related to academic grades across different school subjects (Goetz et al., 2007). The correlation