HIGH SCHOOL STUDENTS' EMOTIONAL EXPERIENCES IN MATHEMATICS CLASSES

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The aim of this qualitative research is to identify Mexican high school students' emotional experiences in mathematics classes. In order to obtain the data, focus group interviews were carried out with 22 students. The data analysis is based on the theory of the cognitive structure of emotions (Ortony, Clore & Collins, 1988) that specifies the eliciting conditions for each emotion and the variables that affect the intensity of each emotion. The participant students' emotional experiences are composed of 1) Satisfaction and disappointment while solving a problem, 2) Joy or distress emotions when submitting a test, 3) Fear and relief emotions in mathematics classes, 4) Pride and self-reproach emotions when grading a course and 5) Boredom and interest in mathematics classes.

INTRODUCTION

In the field of mathematics education, most of the research on students' emotions focuses on its role in mathematical problem solving (Corte, Op 't Eynde, & Verschaffel, 2011; McLeod & Adams, 1989; Schoenfeld, 1985; Madler, 1989; Op 'T Eynde, De Corte & Verschaffel, 2006; DeBellis & Goldin, 2006; Goldin, 2000; Goldin, Epstein, Schorr & Warner, 2011). Among other results, these studies have confirmed that people tend to experience similar emotions in the process of problem solving.

Research on emotions (Hannula, Pantziara, Wæge & Schlöglmann, 2010) has outlined the necessity to move beyond the simplistic view of distinguishing between positive and negative emotions. According to Lewis (2013) there are several reasons why this has not been done: 1) It seems more difficult to build a solid theoretical basis for emotions than for other affective constructs, 2) quantitative analysis, like survey methods, offer multiple possibilities to find cause and effect relationships between attitudes and beliefs. Furthermore, Hannula et al. (2010) and Hannula (2012) also noted the need for research focused on emotions during routine mathematical experiences because most of the research has focused on emotions and intense emotions in non-routine mathematical activities.

In this study we have attempted to analyse students emotions in routine activities and to go beyond a consideration of positive and negative emotions using the theory of the cognitive structure of emotions (Ortony, Clore & Collins, 1988). We are aware that the analysis of narratives of emotional experiences is quite different from the direct

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analysis of emotions, but as Ortony et al. (1988, p.8) we are willing, "(…) to treat people's reports of their emotions as valid, also because emotions are not themselves linguistic things, but the most readily available nonphenomenal access we have to them is through language". This is why we focused on the following research question: *What are high school students' verbal expressions of their emotional experiences in mathematics classes?*

THE THEORY OF THE COGNITIVE STRUCTURE OF EMOTIONS

We have chosen the *theory of the cognitive structure of emotions* (OCC theory from now on) to identify the students' emotional experiences. For Ortony et al. (1988) emotions arise as a result of interpretations of situations by those who experienced them: "[Emotions can be taken as] valenced reactions to events, agents or objects, with their particular nature being determined by the way in which the eliciting situations is construed" (Ortony et al., 1988, p. 13). Thus a particular emotion experienced by a person on a specific occasion is determined by his interpretation of the changes in the world:

> When one focuses on events one does so because one is interested in their consequences, when one focuses on agents, one does so because of their actions, and when one focuses on objects, one is interested in certain aspects or imputed properties of them *qua* objects. (p. 18)

Different types of situations that elicit emotions are labeled in classes according to a word or phrase corresponding to a relatively neutral example that fits the type of emotion (Ortony et al.,1988). For example, to refer to the emotion type "pleased about the confirmation of the prospect of a desirable event" they choose the emotion word *satisfaction* because it represents an emotion of relatively neutral valence among all those that express that you are happy about the confirmation of something expected.

The characterizations of emotions in the OCC theory are independent of the words that refer to emotions, as it is a theory about the things that concern denotative words of emotions and not a theory of the words themselves. From the distinction between reactions to events, agents, and objects, we have that there are three basic classes of emotions:

> Being *pleased* vs. *displeased* (reaction to events), *approving* vs. *disapproving* (reactions to agents) and *liking* vs. *disliking* (reactions to objects). (Ortony et al., 1988, p. 33)

Reactions to events breaks into three groups: one, the Fortunes-of-others group, focuses on the consequences for oneself of events that affect other people. The other two, the Prospect-based and Well-being groups, focus only on the consequences for oneself. Reactions to agents are differentiated into four emotions comprising the Attribution group. Reactions to objects lead to an undifferentiated group called the Attraction group. There is also a compound group of emotions, the Well-being/Attribution compounds, involving reactions to both the event and the agent simultaneously. It seems to be a general progression that operates the different groups

of emotions in order: first reactions to events, then to agents, and finally to objects. From the previous considerations, the OCC theory specifies 3 classes, 5 groups and 22 emotion types. To illustrate in Table 1, we present the corresponding emotions to the Prospect-based group

Class	Group	Types (sample name)
	PROSPECT-BASED	Pleased about the prospect of a desirable event (*hope*)
		Pleased about the confirmation of the prospected of a desirable event (*satisfaction*)
		Pleased about the disconfirmation of the prospect of an undesirable event (*relief*)
		Displeased about the disconfirmation of the prospect of a desirable event (*disappointment*)
		Displeased about the prospect of an undesirable event (*fear*)
		Displeased about the confirmation of the prospect of an undesirable event (*fears-confirmed*)

Table 1: Emotion types according to the OCC theory (a extract)

To interpret emotional experiences in mathematics classes we have added two types of emotions in the Well-being group of emotions to the OCC theory. We call them *boredom* and *interest*. These emotional experiences are elicited by the appraisal that the students made of their own cognitive state: 1) states of *alertness* and *concentration* that produce understanding and learning in the case of *attention*, and 2) states of *distraction* and *deconcentration* that prevent understanding and learning in the case of *boredom*. Thus, we consider boredom emotions like "Displeased about an undesirable cognitive state of distraction" and *interest* like "Pleased about a desirable cognitive state of attention".

METHODOLOGY

Context

The high school where the study was carried out lies to the west of Mexico City. Most of the students live in municipalities bordering the metropolitan area of Mexico City located in the State of Mexico, they come from low economic extraction and most of their parents did not attend college-level. Most students' mothers are housewives.

Due to the inflexibility of the curriculum, all students have the same mathematics schooling path composed of six courses (one per semester) with five hours each class per week: 1) Algebra, 2) Geometry and Trigonometry, 3) Analytical Geometry, 4) Differential Calculus, 5) Integral Calculus and 6) Probability and Statistics. Generally, there is a traditional process of teaching and learning mathematics because

mathematics classes focus primarily on the teacher's explanation and the subsequent resolution of exercises by the students.

Participants

We selected the 22 high school students (ages from 16 to 19 years old, 19 males and 3 females) who are the attending the Analytical Geometry course offered in a for students that have previously failed the course, and did not pass the "sufficiency test" for at least one time. The "ordinary tests" and the "extraordinary tests" are done during regular courses. If the student did not pass the "ordinary tests" has the right to take an "extraordinary test". If the student did not pass the course has the right to take a "sufficiency test" (done outside of regular courses) that is the mechanism by which students can accredit a course based on the demonstration of skills or knowledge through a unique test. The 22 students enrolled in this course agreed to participate in this research. As we had no gender distribution control, it was not taken into account in the data analysis.

Data gathering procedure

Methodologically, we decided to access to the students' emotions from their reports of experienced emotions because the focus of the research is on the students' subjective experiences of emotions. Thus, we carried out four focus group interviews of approximately one and a half hours during the mathematics classes in a regular classroom. We decided to use it because we observed during previous research at the same school that students feel confident and comfortable to express their thoughts, feelings and emotions about various topics in focus group interview.

The questions asked in the focus groups were: 1) Generally, how do you feel in mathematics classes? 2) How do you feel when solving a problem in a mathematics class? How do you feel when you cannot solve a problem in a mathematics class? 3) How do you feel when submitting a test? 4) How do you feel when you know that you failed a mathematics course? And 5) how do you feel when you pass a mathematics course? The role of the interviewers was to deepen on the use, meaning of words and phrases used by the students to answer the questions. Following the OCC theory, our questions intend to provoke students to talk about their emotional experiences in terms of the eliciting conditions.

Data analysis

The videotaped interviews were fully transcribed. In the transcript, students were identified as M*n*-G*k* or F*n*-G*k*. Where M and F indicate that the participant is male or female respectively, *n* (1 to 6) indicates the participant identification number and *k* (1 to 4) indicates the focus group number. Interviewers were identified as MI (male interviewer) and FI (female interviewer). We included explanations in square brackets in order to clarify some of the students' expressions. According to OCC theory to identify a type of emotion we consider three specifications:

1. ***Concise phrases*** that express all the eliciting conditions of the emotional experiences. We highlight with italic bold letters the concise phrases that shows the eliciting conditions of an emotion in the evidence.
2. *Emotion words* that express emotional experience. We highlight with italic letters the concise phrases that show the emotions in the evidence.
3. Variables that affect the intensity of emotions. We underlined phrases that express intensity of the variables in the evidence.

RESULTS

The participant students' emotional experiences are summarized in Table 2.

Eliciting conditions	Emotion types	Variables that affect intensity
Mathematics class	Fear/Relief	Effort Probability
Solve a problem / Not solve a problem	Satisfaction/Disappointment	Realization
Submit a test	Joy/Distress	Effort
Mathematics class	Boredom/Interest	Desirability Arousal
Grading a course / Not grading a course	Pride/Self-reproach	Strength of cognitive unit
Solve a problem on the blackboard / Not Solve a problem on the blackboard		Expectation-deviation

Table 2: The students' emotional experiences

Here as an example, the detailed evidence presented identifying satisfaction/disappointment emotions.

Satisfaction/disappointment

Students experience *satisfaction* emotions (pleased about the confirmation of the prospected of a desirable event) when they are able to solve specific problems. When this does not happen *disappointment* emotions appear (displeased about the disconfirmation of the prospect of a desirable event).

> **M2-G1**: *I feel good* ***when I understand***. I even want to go to the blackboard to answer the problem. But *I don't feel good* when I am trying to do something ***I don't even know***.
>
> **M1-G2**: *I feel happy* ***when I can solve the problem*** because I can do it. In fact, it is very difficult for me and *I feel good if* ***I can***.

M2-G2: *I am satisfied* if **I can solve a problem**. *I am more motivated with* ***the extra points***, I even want more problems.

Satisfaction emotions are affected by the "effort" variable (reflects the degree to which resources were expended in obtaining or avoiding an anticipated event). This occurs when the teacher gives favourable extra points in the assessment of the students that solve a problem, so the students are provoked to strive in order to obtain them. We noted this intensity when the students used the quantity adverb "more" to express a superlative degree of the experienced emotion.

M2-G2: *I am satisfied if* **I can solve a problem**. *I am more motivated with* ***the extra points***, I even want more problems.

The "likelihood" variable (the degree of belief that an anticipated event will occur) also appeared in the belief of a student that he will be able to solve a problem in the future because he has already solved similar problems.

M4-G2: *I feel really cool* because I have already learned how to solve the problem. It will be easier to solve more problems like this.

On the other hand, *disappointment* emotions are also affected by the "effort" variable, because it reflects the degree of sources employed by the students to solve a problem. There are two possible outcomes when students cannot solve a problem: look for help or quit the problem. In both cases, the experimented emotions are more intense. The emotion word associated for not solving a problem is *desperate* (we interpret this as a form of deep disappointment). The following dialogue shows this:

M1-G4: Sometimes I am desperate because **some of my classmates have finished the work and I don't even know what to do or how to begin**. I ask the teacher for help but it is useless because I don't know the previous subjects and the teacher says that I have to do the same. Then *I am desperate* ***when I see that everyone else has finished and I haven't***.

M2-G4: I am desperate if ***I cannot solve the problem and stop trying***. I wait until the teacher explains it later.

DISCUSSION, CONCLUSIONS AND LIMITATIONS

The results focused on the experienced emotions of students are an empirical contribution to mathematics education that helps to fill the gap in research about emotions in their daily lives with mathematics at school. By applying a complex theory of emotions, this research goes beyond a simplistic view that only considers positive and negative emotions.

Our analysis found eight (*fear*/*relief*, *satisfaction*/*disappointment*, *joy*/*distress*, *pride*/*self-reproach*) of the twenty-two types of emotions that the OCC theory considers and two additional ones (*boredom*/*interest*). Because eight of them (*fear*/*relief*, *satisfaction*/*disappointment*, *joy*/*distress*, *boredom*/*interest*) are reactions to events we can conclude that most of the students' emotional experience is related to achievement goals (learn in class, solve a problem, understand the teachers' explanations, interest to learn at class, pass a course, etc.). In contrast, as two types of

emotion (*pride*/*self-reproach*) are reactions related to agents, a minority of experiences relate to "standards, principles, and values" (in the sense of the OCC theory). In addition, we did not find emotions arising from reactions to objects. This can be explained in several ways: First, it can be caused by a methodological limitation because we chose situations through which students had to recall triggering conditions. Well-Being/Attribution emotions may have been told if we had asked, for example: how do you feel when you collaborate with a classmate solving a problem? This methodological limitation is inevitable given the way the situation was presented to the participants. This leads us to consider a different implementation of the OCC theory in empirical research: ask participants for the situations where they experience a specific type of emotion. A possible question for this matter could be: What mathematical situations make you feel afraid/frighten? A similar question could be: In what situations have you been afraid of mathematics? Second, the emotional experiences that we found reflected the participants' circumstances: they are students focused on the goal of passing a course in which they are enrolled for the second time.

The proposed data analysis had the complexity to go beyond emotion words for students to focus on eliciting conditions. We consider that this is a methodological contribution, derived from the OCC theory, to analyze narratives of experienced emotions. Other studies could analyze students' and teachers' narratives as we proposed since it has been proved that *narrative inquiry* is relevant to an exploration of students' and teachers' affect (Di Martino & Zan, 2009, 2011).

A limitation of the OCC theory for an analysis of the emotions experienced by students is that it was originally formulated with no consideration of the specific settings where emotions are experienced. *Boredom* and *interest* are important parts of the emotional experiences in mathematics classes of the participants in this study, but they do not match with any of the 22 types of emotions established by the OCC theory. This shows the necessity to expand and adapt the OCC theory in order to consider specific emotional experiences in the mathematics classes. Future research could focus on other emotions that should be included to capture the complexity of emotions experienced in mathematics at school.

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