Students’ emotional experiences in high school mathematics classroom

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The aim of this qualitative research is to identify Mexican high school students’ emotional experiences in the mathematics classroom. In order to obtain data, focus group interviews were carried out with 53 students. Data analysis is based on the theory of cognitive structure of emotions (Ortony, Clore, & Collins, 1988), which specifies eliciting conditions for each type of emotion and the variables that affect intensity. The participants’ emotional experiences are: satisfaction, disappointment, hope, fear, joy, distress, boredom, interest, pride, reproach, self-reproach, like and dislike with different eliciting conditions. These results show that all students’ emotional experiences are based on their appraisal in terms of a goal structure present in the mathematics classroom and in the school setting.

Keywords: Emotions in mathematics education, students’ emotions, emotions in mathematics classroom, appraisal structures, theory of cognitive structure of emotions.

INTRODUCTION

In the field of mathematics education, most of the research on students’ emotions focuses on their role in mathematical problem-solving (e.g., Goldin, 2000; Op’T Eynde, De Corte, & Verschaffel, 2007). Among other results, these studies have confirmed that people tend to experience similar emotions in the process of problem-solving. By example Op’T Eynde and colleagues (2007) found that students experience different emotions while solving a problem. They can be annoyed, frustrated, angry, worried, anxious, relieved, happy or nervous. First, for instance, a student can be worried during the process of finding a strategy to solve a problem (this is evidenced by students’ use of descriptions such as “brow lowering” and “not feeling well”). The student becomes frustrated if the solution to the problem does not seem to appear after 10 seconds (“I don’t want to use the calculator”, “it does not help me”, “but I still want to reach the goal”). Later, panic appears and finally anger (“come on, what is this all about”).

Research on emotions in mathematics education highlights the necessity to move beyond the view of distinguishing between positive and negative emotions. It is also suggested to go beyond analysing emotions in problem solving and investigating emotions routine activity (Hannula, Pantziara, Wæge, & Schlöglmann, 2010). So we have assumed the task to identify emotional experiences in routine activities in mathematics classes. In order to go beyond a consideration of positive and negative emotions we use the cognitive structure of emotions theory (Ortony et al., 1988). This is the main reason to focus on the following research question: What are the students’ emotional experiences in high school mathematics classroom?

We are aware that the analysis of narratives of emotional experiences is quite different from the direct analysis of emotions but, like Ortony and colleagues (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 non-phenomenal access we have to them is through language”.

THE THEORY OF THE COGNITIVE STRUCTURE OF EMOTIONS

We have chosen the theory of the cognitive structure of emotions (by the initials of the surnames of the authors OCC theory from now) to identify the students’ emotional experiences. For Ortony and colleagues (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 deter-
mined 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” (Ortony et al., 1988, 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.

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 (Martínez-Sierra & García González, 2014). 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 interest, 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”.

<table>
<thead>
<tr>
<th>Class</th>
<th>Group</th>
<th>Types (sample name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactions to events</td>
<td>PROSPECT-BASED</td>
<td>Pleased about the prospect of a desirable event (hope)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleased about the confirmation of the prospect of a desirable event (satisfaction)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleased about the disconfirmation of the prospect of an undesirable event (relief)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Displeased about the disconfirmation of the prospect of a desirable event (disappointment)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Displeased about the prospect of an undesirable event (fear)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Displeased about the confirmation of the prospect of an undesirable event (fears-confirmed)</td>
</tr>
</tbody>
</table>

Table 1: Emotion types according to the OCC theory (an extract)
OCC theory specifies three global variables that affect the intensity of different emotions types, three central variables and nine local variables. They are briefly laid out in Table 2.

OCC theory defines goals as what one wants to achieve. There are three kinds of goals: active-pursuit goals (A-goals), interest goals (I-goals), and replenishment goals (R-goals). A-goals represent the kinds of things one wants to get done, like passing a course or finishing university. I-goals are more routine goals and are necessary to achieve A-goals or support them, like passing a test. R-goals are those that should be satisfied from time to time in a cyclical nature, like attending a class. Furthermore, it is important to distinguish between all-or-nothing goals, like passing a test, and partially attainable goals, like solving a problem. These distinctions allow oneself to determine the intensity of the different experienced emotions.

**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 53 regular students for the study (aged between 16 and 18 years, 29 men and 24 women). They were in their fourth semester. Participation was voluntary. We chose this type of participants because given his age we believe they would be able to verbalize their emotional experiences. And since they have completed more than one year in high school, they would be able to inform us their experiences in math class in high school. The participants were officially registered in their fourth semester in the Differential Calculus course, which focuses on developing algebraic skills to study elementary Differential Calculus. The topics of this course are: (1) functions, limits and continuity, (2) algebraic functions derivatives and (3) transcendental functions derivatives.

**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 nine focus group interviews of approximately one and a half hours during the mathematics classes in a regular classroom. We decided to use it because

<table>
<thead>
<tr>
<th>Class of emotions</th>
<th>Group of emotions</th>
<th>Local variables</th>
<th>Central variables</th>
<th>Global variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactions to events</td>
<td>Fortunes-of-others</td>
<td>Desirability-for-other</td>
<td>Desirability (evaluated in terms of goals)</td>
<td>Sense of reality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liking</td>
<td></td>
<td>Proximity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deservingness</td>
<td></td>
<td>Unexpectedness</td>
</tr>
<tr>
<td></td>
<td>Prospect-based</td>
<td>Likelihood</td>
<td>Praiseworthiness (evaluated in terms of standards)</td>
<td>Arousal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Effort</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Realization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Well-being</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactions to agents</td>
<td>Attribution</td>
<td>Strength of cognitive unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expectation-deviation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactions to objects</td>
<td>Attraction</td>
<td>Familiarity</td>
<td>Appealangness (evaluated in terms of attitudes)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Variables affecting the intensity of emotions according to the OCC
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.

For some researchers, individual interviews are more appropriate because emotions are personal. For others, focus group interviews are better because the interaction with others, who potentially feel the same, allows more free expression (Krueger, 1994). In this regard Krueger (1994, p. 20) mentions that “the focus group presents a more natural environment than that of an individual interview because participants are influencing and influenced by others just as they are in real life”. Thus we consider that, in our research, the conducted focus group interviews are the correct choice. This is because our research goal is to identify whole participants’ emotional experiences; it is not our goal to identify the emotional experiences separately for each of the participants.

The questions asked in the focus groups were: 1) What feelings or emotions do you experience about mathematics? Why do you feel this? 2) What feelings or emotions do you experience in the mathematics classroom? Why do you feel this? 3) What feelings or emotions do you experience just before a mathematics class? And later? Why do you feel this? 4) What feelings or emotions do you experience when you learn mathematics? And when do you not learn? Why do you feel this? 5) What feelings or emotions do you experience when you solve a mathematical problem? And when you cannot? Why do you feel this? 6) What feelings or emotions do you experience in a good mathematics class? And in a bad class? Why do you feel this? 7) What feelings or emotions do you experience when a mathematics teacher is explaining? Why do you feel this? 8) What feelings or emotions do you experience for a good mathematics teacher? And for a teacher that is not good? 9) What feelings or emotions do you experience in a mathematics assessment? Why do you feel this? 10) What feelings or emotions do you experience in a mathematics test? Why do you feel this?

Two collaborators of the author conducted interviews. One is a PhD student in the field of mathematics education with experience in data analysis using the OCC theory (she is coauthor of the research of Martínez-Sierra & García González (2014)). The other interviewer is a research assistant with experience in conducting individual interviews and focus group interviews. Both interviewers are outside the everyday context of students. The analysis was conducted by the author and discussed with the PhD student. Considering that triangulation the author wrote this version of the analysis.

Data analysis
The videotaped interviews were fully transcribed. In the transcript, students were identified as Mn-Gk or Fn-Gk: M and F indicate that the participant is male or female; n (1 to 5 or 6) is the participant identification number; Gk (1 to 9) indicates the focus group number. 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
Table 3 shows the students’ emotional experiences in the mathematics classroom.

To illustrate in the following we show in detail the evidence related disappointment emotions.

DISAPPOINTMENT EMOTIONS
Not being able to solve problems
Disappointment emotions are triggered when the interest goal of solving problems is not attained.

M4-G8: I get angry, stress and with a headache if I am not able to solve a problem, because I cannot reach a solution.

There are two local variables that affect intensity of disappointment emotions: effort and probability.
The effort variable reflects the number of resources that the student uses to solve a problem. These resources depend on the kind of problem; for example, the student can ask their teacher or classmates for help during classwork, but this is not possible in a test.

**F2-G8: When I am not able to solve a problem then I ask myself what to do because I didn’t understand anything, so I ask for help from my teacher or a classmate.**

A student can choose whether or not to solve a problem in a test. The student who chooses to solve it spends more time on it in order to reach a solution. This effort is linked to the interest goal of passing the test. If this goal is attained then it could trigger future active goal attainments like passing the course.

**M1-G8: If the problem is in a test, then I will go to the extraordinary test.**

The probability variable reflects the degree of a student’s belief that they will pass a test due to the solution of a problem. Disappointment emotions are more intense when the student believes that not passing the test is a consequence of not being able to solve a problem.

**M1-G4: I feel bad when I cannot solve a problem in a test, and I am constantly thinking of it until I get my grade. I get angry and depressed.**

**DISCUSSION AND CONCLUSIONS**

We found statements about 12 of the 24 types of emotions in our extended OCC theory. Except for fears confirmed emotions, we confirmed the presence of all emotions in the prospect-based group (satisfaction, relief, disappointment and fear), well-being group (joy, distress, boredom and interest), attribution (pride, self-reproach and reproach) and attraction group (liking and disliking).

There are three variables that intensify the prospect-based emotions triggered by the confirmation (satisfaction) or refutation of prospective situations (displeasure, hope and

<table>
<thead>
<tr>
<th>Group</th>
<th>Type of emotion</th>
<th>Triggering situations</th>
<th>Variables that affect intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROSPECT-BASED</td>
<td>Satisfaction</td>
<td>Being able to solve a problem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hope</td>
<td>Not being able to solve a problem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fear</td>
<td>Not understanding Fearing mathematics class Not passing a test</td>
<td>Desirability</td>
</tr>
<tr>
<td></td>
<td>Joy</td>
<td>End of class Being able to solve a problem at the blackboard</td>
<td>Desirability</td>
</tr>
<tr>
<td>WELL-BEING</td>
<td>Distress</td>
<td>Not being able to solve a problem in class Not being able to solve a problem in a test Going to the blackboard</td>
<td>Desirability</td>
</tr>
<tr>
<td></td>
<td>Boring</td>
<td>Not understanding the teacher’s explanation Being in a non-dynamic class</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest</td>
<td>Being able to understand teachers’ explanations Having a positive attitude towards the teacher Being motivated to pay attention</td>
<td>Desirability</td>
</tr>
<tr>
<td></td>
<td>Pride</td>
<td>Passing a course Being able to solve a problem</td>
<td></td>
</tr>
<tr>
<td>ATTRIBUTION</td>
<td>Reproach</td>
<td>Reproaching the teacher</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-reproach</td>
<td>Not being able to solve a problem</td>
<td>Expectation-deviation</td>
</tr>
<tr>
<td></td>
<td>Liking</td>
<td>Understanding mathematics Being able to solve a problem</td>
<td></td>
</tr>
<tr>
<td>ATTRACTION</td>
<td>Disliking</td>
<td>Not being able to solve a problem</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Students’ emotional experiences in a mathematics classroom
fear): (1) the desirability of a situation based on the attachment of a goal (such as solving problems), (2) the degree of belief that a prospective situation will actually occur (such as passing a test) and (3) the number of resources used to obtain or avoid a prospective situation (such as solving a problem in a test).

Well-being emotions are intensified by the desirability of the achievement of goals. Each goal is valued according to the goal structure of the student. The degree of this desirability is related to the degree to which the person expects positive consequences from the event. So, intensity of joy and interest emotions increases with desirability. On the other hand, intensity of distress and boredom emotions increases as desirability decreases.

In attribution emotions, pride is intensified in the event that the student follows the rules in their context. For example, a student will feel proud for the effort put into solving a problem or passing a course if this effort is worthy by itself. Intensity of reproach and self-reproach emotions increases depending on the deviation of the expected roles of students and teachers, as in the case of failing a course due to the teacher’s actions.

Attraction emotions are intensified by the amount of time students have been attending mathematics courses. The number of courses attended affects students’ emotional response: some of them consider mathematics to be a difficult but nice course and others simply don’t like it. This is not a transitory appraisal; it is the consequence of their academic life, which is still in formation and which influences their beliefs about mathematics.

We only found three types of goals that trigger all students’ emotions in this context, even when OCC theory states different appraisal structures for each type of emotion. These goals are: active-pursuit goals (A-goals), interest goals (I-goals), and replenishment goals (R-goals). Their final structure is shown in Diagram 1. So, each situation has an implicit or explicit goal that triggers an emotion. This emotion will be positive or negative depending on whether the goal is achieved or not.

In Diagram 1 we express the different relationships between goals with arrows. An arrow from one goal to another means that the first goal may directly affect the achievement of the second goal. For example, passing a test is a goal that affects both passing a course and finishing high school. The diagram also expresses different ways to achieve a goal. For example, understanding teacher’s explanations, paying attention in class or attending classes can help with the achievement of solving problems. Furthermore, the letter N above an arrow denotes that the first goal is necessary to achieve the second goal; the letter F denotes that the first goal facilitates the achievement of the second goal. For example, passing high school is a necessary goal to study at university and it facilitates getting a job.

Altogether the goal structure is an inherent part of the students’ high school tradition. Goals can be explicit or implicit. The goal structure can be taken as part of the “didactic contract” (understood as “the set of specific behaviours of the teacher which are expected by the student and the set of behaviours of the students which are expected”, Brousseau, 1997, p. 31), because it influences, along with the emotional reactions, the

![Diagram 1: Students’ structure of goals](image-url)
expected behavior of students and teachers in class. So, students direct their emotions in order to stimulate and guide their conduct to achieve goals that are implicitly or explicitly established in the mathematics class. This is consistent with the perspectives that highlight the complementary relationship between emotion and motivation in learning and performance (e.g., Kim & Hodges, 2011).

Finally, we consider that it is necessary to keep investigating students’ emotions (and teachers’) in different academic settings and at different school levels. Appraisal theories could help to identify the specific appraisal structure for each academic setting and school level. In this sense, we consider that people experience the same emotions but with quite different appraisal structures even if each individual values an event depending on their own appraisal structure.

REFERENCES


