

A Qualitative Multiple Case Study of an Integrated Cognitive Model of Emotion Generation

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Abstract

There is a growing consensus that emotions are the product of modularized goal oriented cognitive processes. With this assumption in mind, we applied a cognitive model to analyze the generation of negative emotions induced by events in a group of university students. The model emphasizes the importance of cognitive processes that can lead to emotions being perceived as threatening and stress inducing. Within this cognitive framework the concepts of appraisal and goal play an important role as well as two routes for the emotion generation: the schematic and the associative route. Data were collected by interviewing 24 university students. The interview protocol contained specific questions that allowed us to assess the interviewees' experiences and emotions related to mathematics in childhood and young adulthood. We created a coding framework based on the cognitive model we adopted, which includes categories pertaining to mathematics-related events, their appraisal and generation of emotions. Three participants described their negative experiences related to mathematics classes in childhood and young adulthood. The appraisal of these early experiences had a profound impact upon the participant's emotion generation in later life. The main findings highlight the role of cognitive mechanisms for emotion generation.

Keywords: emotion generation, cognitive processes, SPAARS, mathematics education, prospective primary teachers

1. Introduction

Life events (LEs) refer to experiences that disrupt the course of everyday living or ongoing stressful circumstances that have an impact on health and psychological well-being (Holmes & Rahe, 1967). Recent developments have led to an increased interest in the early identification of negative emotions generated by LEs in student populations (Eligio, 2017; Hannula, 2020). This is justified on the basis that a strong relationship between negative LEs and psychopathology has been established (Cleland et al., 2016), a finding that has been extensively discussed in cognitive theories of emotion (Lazarus, 1991; Oatley & Johnson-Laird, 1987; Oatley, 1992; Oatley & Duncan, 1992; Power & Dalgleish, 2020). LEs require adaptation to change and adjustment to daily life over extended periods of time and failure to do so could be detrimental to a person's well-being and quality of life. Additionally, emotions facilitate memory, direct attention, guide behavior and help us adapt to life changes (Pekrum & Stephens, 2010; Du Toit, 2020; Hitchcock, 2019; 2020). However, when adverse LEs are experienced by students who do not have the means to manage or resolve them, emotions can become dysfunctional and create obstacles to their plans.

LEs consist of two components: the cognitive component, which includes the evaluation of goals and plans, and the affective component, which refers to how frequent and how intense the generated positive or negative emotions are. The impact on these two components depends on the type of event experienced; for example, some events may have a greater impact on cognitive functioning while having little impact on emotional well-being (Schimmack, 2008; Busseri & Sadava, 2011; Kettlewell, et al., 2020; Luhmann, et al., 2012). These two components create the construct of the subjective well-being of the person (Diener et al., 2017) which refers to the ability of an individual to cope with stressful LEs to adapt and work productively. Cleland et al. (2016) showed that LEs have both detrimental and beneficial consequences on well-being because they could interfere with ongoing living, and require adjustment to new circumstances temporarily or permanently.

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1.1 Categorization and basic function of stressful life events

Young individuals' predominant responses to LEs have demonstrated that the way young individuals use to deal with daily difficulties predicts the manner of dealing with adverse LEs in later life. Compas (1987) was among the first to classify stressful events into two broad groups: acute and chronic. Acute stressful events include specific, significant or critical LEs, extraordinary unexpected events, and everyday minimal events whereas; chronic stressful events include long-term situations of personal degradation or deprivation (e.g., poverty). Other categorizations view LEs as falling into two broad categories: critical life events and daily hassles that cause anxiety, stress and disturbance (e.g., Alder, 2005). Lazarus and Folkman's seminal work (1984) contributed to this area by approaching stress inducing LEs from the perspective of daily hassles.

Many empirical studies have found that everyday hassles incorporating events with friends, family, and pressure from high academic standards or failing in exams have more negative effects on the mental and physical well-being when compared with major LEs (DeLongis, et al., 1988; Uijtdewilligen, et al., 2014). These are issues brought by students to counseling centers (Folkman & Lazarus, 1988; Dwyer & Cummings, 2001).

An additional categorization of stressful LEs has been based on the child's developmental stage. For example, in preschool age children often encounter separation anxiety, in school age there may be problems with the school environment and performance, difficult relationships with peers and classmates, pressure for good performance from parents or even family problems. In adolescence and young adulthood there are problems with exams anxiety, entrance to tertiary education etc. (Roeser, et al., 1998; Rappo, et al., 2017; de Lijster, 2019).

1.2 Life Events in Tertiary Education Environments

Early life experiences often have a profound impact on students' emotions and on how they believe these experiences will shape their future emotional expressions. Individuals who experience negative LEs in childhood may be more prone to experiencing emotional problems than others later on in life (Margalit, 2003). Longitudinal studies have shown that the co-occurrence of depression and anxiety in childhood can lead to full-blown depression in adulthood (Carballo et al., 2011; Lähdepuro et al., 2019). Different aspects of LEs in an academic setting may affect young people's well-being through various mechanisms, such as variations in academic performance, aspects of the academic environment, and teachers/lecturers' attitudes.

University life is a period in young adulthood where new experiences take place in a stimulating environment with newly established friendships, different academic and curricular activities and at the same time students are exposed to various pressures. Undergraduates face new challenges which might contribute to increase the levels of discomfort, diminish academic performance or emotional and physical wellbeing (Sheldon et al., 2021). Some LEs that may be the cause of negative emotion generation among undergraduates include difficulty to understand the educational content and workload from unclear or difficult assignments (e.g., Nerdrum et al., 2009), feelings of incompetence or poor motivation to learn (e.g., Silva et al., 2017), time pressures and sleeping habits (e.g., Semplonius & Willoughby, 2019).

During mathematical activity, emotional states interact with cognitive and environmental factors. One of the emotions that has been widely recorded in mathematics education is anxiety. In the 1970s, mathematics related anxiety was defined as a branch of anxiety research, specific to the experience of fear in relation to mathematics (Richardson & Suinn, 1972). Students suffering from mathematics anxiety tend to deploy avoidance behaviors, learn less when exposed to the subject, and record performance decline in comparison to their peers. The negative relationship between anxiety and mathematics performance has been found to be stable across all educational levels (Hannula, 2020; Eligio, 2017).

2. Emotion Generation in Cognitive Appraisal Theories

Appraisal is a cognitive process that refers to the evaluation of the individual's interaction with the environment in relation to their goals, their beliefs, the meaning of the events and the expectations that is central in the emotion generation (Smith & Lazarus, 1993; Frijda, 1993). Lazarus (1991) defines the concept of "appraisal" as a complex, high level cognitive activity referring to how the individual perceives the stress inducing LEs and the resources available to manage them.

Appraisal takes place in cycles (primary, secondary, tertiary), with each cycle progressively elaborating the event experienced. Appraisal evaluates compatibility of goals, availability of resources to cope, etc. (e.g., Lazarus, 2001). Primary appraisal involves an initial assessment of the event as neutral, negative, or positive. There are three types of primary assessment: appraisal of the person's togetherness (assessment of the environment), appraisal of the concurrency of the person's goals (assessment of whether a goal is facilitated or prevented), and assessment of whether the event affects self-esteem, life plans, etc.

The secondary appraisal evaluates the coping strategies and resources available to resolve the situation, as well as possible changes in the primary appraisal to allow the person to adapt and find solutions. Two types of secondary appraisal facilitate the person's ability to find solutions: emotion-focused strategies to minimize negative emotions and problem-focused strategies to solve the problem. For example, if a student has the resources to cope with an anxiety-provoking exam, it is perceived as less threatening; if a student does not have the resources to do well on the exam, it is perceived as threatening. In the third cycle, a reappraisal and matching of available resources takes place. After the three appraisals, emotions generated can feed back into the appraisal process, e.g., when students are angry at the teacher and then feel guilty after judging the anger as inappropriate (Lewis & Granic, 1999; Scherer, 2001).

2.1 Emotion Generation within the SPAARS model

Power and Dalgleish (2020) define emotions as psychological processes that guide a person's cognitive system in solving goal-related problems; consequently, the emotions experienced by an individual depend on the extent to which her/his goals are achievable or not. Power and Dalgleish's model is self-organized, multilevel, and uses the four types of representations within the cognitive system for emotion generation: Schematic, Propositional, Analogical and Associative Representation Systems, hence SPAARS. The appraisal of the experienced events in relation to a person's goals as well as the seven components of emotion generation (life event, interpretation, appraisal, physiological change, action tendency, conscious awareness and overt behavior) are important parts of the model. Within the SPAARS framework, emotions may be generated via two routes: the schematic level of representation and the associative level of representation. The process of inhibition occurs between the different levels of representation, in which disturbing behaviors, attitudes and views are prevented from entering consciousness (Dalgleish, Mathews & Wood, 1999). Central to the model is the notion that each emotion exists as an independent module that influences mental activity and action planning. If basic emotions develop in a dysfunctional way, the SPAARS framework proposes that this could lead to the development of emotional disorders.

According to SPAARS (Figure 1), the processing of a LE begins at the sensory level (visual, auditory, etc.). The derivative of this process is transferred to the three representational systems working in parallel: the schematic, the propositional, and the associative levels. At the schematic level, an appraisal of events in terms of important goals and possible changes needs to be constructed. Information from other levels of the system flow into this level. Perception, attention, and memory are biased in favor of information congruent with the dominant schematic models. Commutative schematic models for the self in relation to others take place in childhood, are inhibited, but may surface under stressful stimuli. At the associative level, no actual appraisal process takes place as the event is experienced; this process occurred in the past, was recorded in autobiographical memory, and is retrieved in the associative system. At the propositional level, the events are processed in a semantic way, without emotions being generated. Thus, generation of emotion occurs only at the schematic and associative levels.

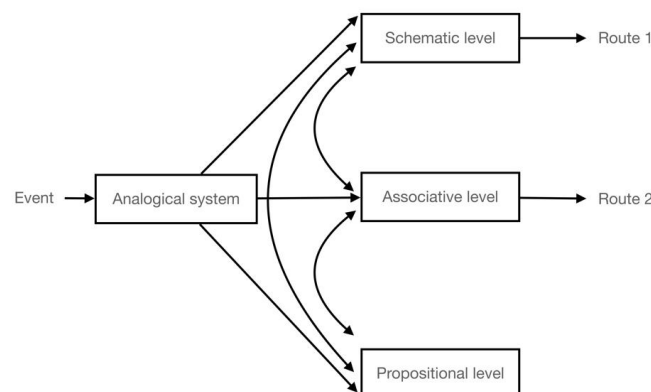


Figure 1: Generation of Emotions via the Schematic and the Associative level of representation (adapted from Power & Dalgleish, 2020, p.572)

In the first pathway of emotion generation (the schematic level), there is an active processing and appraisal of LEs in relation to the individual's goal. The second pathway involves direct, rapid, automatic emotion via the associative pathway, leading to the repetition of the binary relationship between event and emotion. Emotions that arise in the second path always occur in the presence of an event, do not change easily, are rigid, and have direct access to past evaluations in autobiographical memory. The process is similar to learning a skill such as driving a car, which is automatic after some practice. In the case of an anxious person, automatic associative processing of an event produces anxiety, even if the appraisal route evaluates the event as non-anxious.

These associative responses are developed in childhood and stored in autobiographical memory (Moors, 2010; Power & Dalgleish, 1999).

2.2 The process of Inhibition within the SPAARS model

Under normal conditions, individuals process negative LEs and incorporate them into their selves as they change their goals to adapt to new conditions. However, to cope, an individual may attempt to keep the negative experience away from the self in a dissociated state, inhibitory process protects the self and the achievement of important goals (Dalgleish, 2004). The inhibitory process is critical to emotion formation because the person becomes vulnerable to emotional disorders when the events experienced are consistent with the inhibited negative experiences (Elliot & Lassen, 1997; Dalgleish et al., 1999). Inhibitory processes occur at all levels of representation, consciously and unconsciously, in all cycles of evaluation in the generation of emotions. The person's learning history, in which the activation and deactivation of emotion modules becomes dysfunctional, could inhibit the expression of emotions. The SPAARS model borrows the concepts of inhibition and dissociation from the psychoanalytic theory and that's one of the interesting aspects of it.

3. Study aims

The above literature illuminates the importance of LEs as a construct for generating emotion in children, adolescents, and young adults. Until recently, there has been little theoretical and empirical understanding or consideration of the properties that LEs hold in relation to the generation of positive and/or negative emotions. In addition, there has been little empirical application of the SPAARS cognitive model and its components to explain the developmental pathway for emotions generated by experiencing negative LEs in educational settings. In this paper, we focused our efforts on understanding the generation of emotions in a group of university students by highlighting the ways they interpret and appraise past and current LEs in relation to their learning of mathematics. In particular we explored how negative mathematics-related events experienced in primary and secondary education pertains to the ways undergraduates interpret the current mathematics-related life events and whether the schematic or the associative route are activated for the emotion generation.

By adopting a qualitative approach, we analyzed the accounts of three cases selected from a group of 24 participants. We focused on mathematics-related LEs that generate emotions from the pool of "basic" emotions, as well as developmental perspectives and pathways leading to emotion generation according to the SPAARS model (Power & Dalgleish, 2020) which functioned as a useful tool for understanding the underlying mechanisms as well as, the interplay between mathematics-related LEs, cognitive processes, and emotion generation.

4. Methodology

4.1 Research Design Overview

The research project associated with this study was funded by the University's Research Grants Committee. Two main objectives were pursued in the conception and design of the study. The first was to contribute to the state of knowledge about the generation of emotions in tertiary educational institutions where mathematics is part of the curriculum. The second relates to our efforts to capture, identify, and subsequently address the issues that students face in mathematics. In meeting the study's objectives, we followed an exploratory multiple-case study design (Yin, 2018) and conducted in-depth interviews with 24 undergraduates from a primary education department. During the interviews, participants were asked about their past and current mathematics-related life events (LEs) and the emotions associated with them. Data were analyzed by following a Qualitative Content Analysis approach. In the following subsections, we describe in detail the context and recruitment process, the study participants, the data collection process, ethics, and finally our analytical approach.

4.2 Context

The study took place at a Department of Primary Education (DPE) in Greece. Bachelor's degree duration in the DPE is four years (approximately 70 modules) and offers modules in areas such as theory of education and curricula, educational psychology, research methodology, teaching methodology, educational technology, humanities, social sciences, and STEM education (science, technology, engineering and technology). The DPE offers a variety of modules covering a wide range of mathematics that are considered typical for an undergraduate degree in primary education. To graduate, students must successfully attend at least three modules in mathematics (two compulsories, one compulsory elective). During their fourth year, undergraduates have their two-part school practicum, (one for each academic semester) during which they practice observation and teaching, design teaching materials, and reflect upon the process of teaching and learning.

4.3 Participants and recruitment process

Cases were sought from the DPE's undergraduate population who had attended at least two modules in mathematics and had -preferably- started or completed part of their practicum. An initial list of 60 potential participants was compiled by the two authors and a personal invitation was sent to them via email. In total, 24 undergraduates agreed to participate in our study (40% response rate, average age = 21.2 years, average year of studies = 3.5 years, 92% identified as a female). No incentives or other forms of compensation were provided to students for participating in the interviews. In this paper, we present results for three cases. These were selected from the pool of 24 participants based on being representative cases of dissociation, somatization, and associative emotion generation.

4.5 Data collection and Ethics

At the beginning of the study, an ethical clearance checklist was submitted and approved by the University's Research Ethics Committee (approval decision number: 27/24.02.2022). Data were collected by interviewing 24 undergraduates from the DPE during the Spring term of 2022 (31/3/2022 - 16/5/2022). The in-depth interviews were semi-structured and were conducted by the second author. Each session lasted between 30 and 60 minutes, with an average interview time of 40 minutes. Due to restrictions posed at the time because of the ongoing pandemic, all interviews were undertaken via video-conferencing software (Zoom). At the beginning of each session, the participants were informed that for practical reasons the interview will be recorded and they were reassured of confidentiality and anonymity. It was also emphasized that they were free to refuse to answer a question or to withdraw at any time. Participants were then invited to carefully read and digitally sign a consent form following the Declaration of Helsinki. The aspect of anonymity and confidentiality was repeated several times during each interview; this allowed us to build a trustful relationship with the interviewees, which enabled the undergraduates to feel comfortable and speak freely.

The interview protocol contained two groups of questions. The first group included various demographic questions (age, year of studies, mathematics modules attended) whereas the second included open-ended questions aimed at eliciting answers related to participants' life events and difficulties with mathematics ("How would you describe your relationship with Mathematics?", "What kind of difficulties did you encounter in school?", "What kind of difficulties have you encountered so far at the university?", "Can you recall any particular event?") and, their emotions while experiencing these events ("How did you feel when this happened?",

"What were your thoughts when this happened?"). Although the first question from the second group was initially intended to be used as an "ice breaker", it proved to be the question eliciting richer data, thus in subsequent sessions the interview protocol was structured around this question. Given the semi-structured nature of the sessions, throughout each interview, the interviewer used various prompting and probing questions to explore interesting and important issues raised by the participants ("You mentioned earlier that...", "What do you mean by...?", "Can you elaborate more on this?"). All interviews were transcribed verbatim by using the built-in transcription tool of MAXQDA 2020 (VERBI Software), while after each session field notes were made.

4.6 Data analysis

All interviews were fully transcribed and entered as text in the qualitative analysis software MAXQDA2020 (VERBI Software). Digital files from each interview were then destroyed. Any reference to participants' or other people's identities mentioned in the interviews were removed. Participants were assigned alphanumeric codes (S01, S02, S03, etc.) representing each interview's order. Other people's names mentioned in the interviews were replaced with square brackets and a unique, random letter (e.g., [L]). Cases included in this paper correspond to participants S06 (Case 1), S19 (Case 2), and S23 (Case 3). Field notes made during the data collection period were entered as memos in MAXQDA2020.

Our analysis was conducted by following a qualitative content analysis (QCA) approach (Schreier, 2014). At the core of QCA lies the coding frame, a hierarchical structure of codes aiming at classifying all data as instances of a set of aspects related to the research question(s). A coding frame consists of at least two levels: the main categories (the aspects on which a researcher wants to focus her/his analysis) and the subcategories (instances of what is said about the main categories). The coding frame was built as follows (Schreier, 2014): (a) parts of the data relevant to the research questions were selected; (b) main categories were decided and defined; (c) subcategories for each main category were generated and; (d) the coding frame was revised and expanded until it covered all the variation in the data. Based on the study's objectives and theoretical underpinnings, four main categories (life event, appraisal, schematic emotion generation, associative emotion generation) were created (Table 1).

Table 1: The main categories of the coding frame**Life Event**

Description: Incidents requiring adjustment to everyday living either permanently or temporarily have the potential to be detrimental to health and well-being (Oatley & John Laird, 1987; Oatley, 1992; Lazarus, 1991; Dalgleish, 2004).

Indicators: Life events are identified by participants when they describe an experience happening in their life

Example: “...I couldn't respond well to this way of teaching because... he basically gave us an hour before the class to write in the e-class to write in a... he said "chat room" [...] we had to... write our questions and he basically answered them in... in an hour or half an hour...” (S13)

Appraisal

Description: The process of the interpretation of experienced LEs in relation to the individual's goals. Appraisal checks goal compatibility, uncertainty for future completion of goals, inadequate resources to cope, etc. (Arnold, 1960; Lazarus 1991; 2001).

Indicators: An appraisal is identified by participants when they analyze their goals in relation to life events experienced.

Example: “I decided my next essential steps so to speak... what I want to do in my life... I realized that I have to try a little harder because... the master's degree will be... much more difficult and demanding... so I say... if you don't get into this process from now on trying harder than you've been trying... then you're going to have a lot of work piled up...” (S08)

Schematic Emotion Generation

Description: Active processing and interpretation of an event in relation to an individual's goal emotions generated when goal changes are appraised and construed (Power & Dalgleish, 2020).

Indicators: Schematic emotion generation is identified by a participant when she/he generates emotion after appraising the event experienced.

Example: “...I didn't really like the process; I didn't really understand a lot of things... [...] well, it was quite demanding, I didn't really understand, there was an intense approach to the class... this used to stress me out a bit, it was a lot... that's what I remember then... [...] something I won't do in my class because he made me being afraid to ask something...” (S16)

Associative Emotion Generation

Description: Emotions generated via a direct, rapid, automatic and associative route through the associative path also included automated emotion reactions that no longer require effortful processing (Power & Dalgleish, 2020).

Indicators: Associative emotion generation is identified by participants when they express in an automatic and rapid manner an emotion and make inferences from the past and/or generalize for the future.

Example: “...my relationship with mathematics is perhaps a relationship of fear [...] this started in primary school... I specifically remember a teacher who... [...] had told my mom that... "when I ask her something related to mathematics, I see she tightens up, distances herself, keeps a distance in general...” (S22)

Both main categories and subcategories were theory-driven codes i.e., they were defined inductively and reflect concepts derived from the SPAARS model. Segments related to life events and appraisals were coded by applying the corresponding definitions from the literature. The coding of segments regarding participants' emotion generation routes (associative or schematic) was performed by carefully examining a participant's account of a life event and inferring whether participants were appraising the current event or whether they were accessing/recalling the appraisal of a past life event (Figure 2).

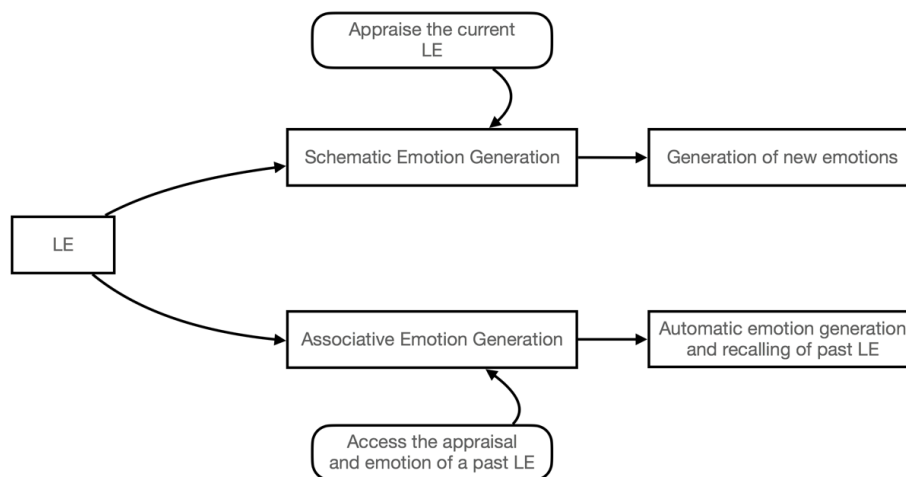


Figure 2: The process of inferring each case's emotion generation route

5. Results

In order to facilitate the presentation of findings in a consistent manner, we have selected excerpts from each interview demonstrating each case's history of LEs. Excerpts are organized according to the seven components of the affective process (life event, interpretation, appraisal, physiological change, action tendency, conscious awareness and overt behavior). This structure does not imply a one-to-one correspondence between a life event and the rest of the components, since we did not have data for all the components. This was a conscious decision and relates to the interview protocol used: all participants, were asked to describe their overall experience with mathematics and offer their account of specific events and emotions related to these events. Following that, we infer the cognitive processes taking place for emotion generation according to the model of SPAARS by Power and Dalgleish (2020).

5.1 Case 1

Case 1 aged 22, was in her/his fourth year of studies when interviewed. She/he had successfully attended all four compulsory and elective compulsory modules in mathematics. Case 1 completed the first part of the practicum and was currently doing the second. From our discussion it became apparent that her/his learning trajectory included distressing events which had an impact upon her/his attitude towards mathematics. All the recalled events were related to the attitudes, behaviors and teaching methodology adopted by her/his former teachers (primary, secondary) and current mathematics lecturers at the university. Case 1 attempted to cope by gradually distancing her/himself from mathematics in order to protect the self and the completion of important goals. She/he gradually reached a point where mathematics didn't exist for her/him.

5.1.1 Components of the Affective Process

Life events. During the interview, Case 1 described four specific events that took place during her/his elementary school years, middle school (gymnasium) and now at the university. Case 1 vividly recalled her/his elementary school teacher's pedagogical approach for children who were not able to comprehend mathematics:

...we had a teacher somewhere in the fourth/fifth/sixth grade, sometime around then, I can't remember now exactly... which I think... this is when I kind of lost it, because she didn't treat us nicely during our mathematics lessons... to pupils not understanding mathematics... she would invite them on the blackboard in order to solve exercises in front of the class...

In middle school, Case 1 mentioned a mathematics teacher whose instruction was insufficient as was his overall class control:

...in middle school we had a teacher who was completely indifferent... who never explained properly the concepts or the theory or taught us anything... we just walked into the class and we'd get out of class... and then we'd write some tests... obviously nobody was performing well at all, which was reflected in our grades... [...] ...sometimes he would just walk into the classroom, mark who was attending ... some students were disobedient and there was a constant disturbance... and just like that half an hour would have pass... then he would open the book, he would do an exercise by himself on the board [...] and that was the end of the class...

After entering university, Case 1 attended two compulsory modules which focused on didactical aspects of mathematics in elementary schools. Although Case 1 mentioned having a relatively unproblematic experience with these, that was not the case with modules focusing on the theoretical side of primary mathematics. Case 1 vividly recalled having issues with the lecturer's teaching approach:

...every time I had to attend a class, I was very anxious, to be there exactly at 8:30 am because after that time he wouldn't let students in, whether you had a good excuse or not e.g., you missed the bus ... the lecturer was talking for three hours straight and I was noticing the eyes of all my fellow students staring at the void... if not all, most of them...

When asked whether she/he remembers specific difficulties faced, Case 1 replied:

I remember that I didn't understand a thing, I remember that we did stuff that I had never encountered during my school years... they were totally unfamiliar to me, neither the specific mathematical concepts nor the chapters covered, nothing, I couldn't remember a thing...

Case 1 also recalled what happened for the same module when, during the pandemic, the lecturer decided to structure his online teaching in a fully asynchronous manner, an approach that caused great distress:

During the time of the pandemic, we had to attend lectures online, the lecturer never did an online lecture, I mean we never met to talk, he was just uploading slides, other material and problem sheets... which all were unknown to me... unknown... just that...

Interpretations. The experienced LEs throughout Case 1's developmental path were interpreted in ways that led her/him to believe that she/he won't be able to teach mathematics effectively during her/his practicum or that she/he will not manage to obtain her/his bachelor's degree on time. For example, when asked to reflect upon the impact that the experienced LEs in mathematics had upon her/him, Case 1 answered that she/he developed an aversion for mathematics and added:

I had very good grades throughout my school years and it annoyed me that I was behind only in this subject while in everything else I was very good...

Appraisals. Some of Case 1's experiences were appraised as a threat to her/his goals of successfully teaching mathematics in the practicum, passing a mathematics module or even obtaining her/his bachelor's degree on time. For example, when asked how she/he prepared for her/his practicum classes, Case 1 replied:

So, I spent a lot more time studying and preparing for my mathematics classes...in comparison with the time I devoted for other subjects... because I wanted to be sure when teaching mathematics... that I am the right person to teach my pupils... because in my experience, the teachers I had, they were not suitable for teaching me and I didn't want to become like them... to achieve this, I was devoting more time, I was trying to be properly prepared ...

Physiological changes as reported by participants. Every mathematics-related experience led to the activation of the physiological system associated with fear and anxiety: Case 1 felt constantly irritated, feeling nausea leading to upset every time she/he was facing mathematics and thought that she/he would not be able to cope with the pressure felt on every encounter with mathematics. For instance, when directly asked whether she/he feels anxious about mathematics, she/he replied:

Now I'm in the practicum and... I have to teach mathematics... while other subjects are very easy for me, to prepare, to study, to design activities for the pupils... in mathematics I don't know why, I can't do it... I feel too much irritated... and I feel ill ... I think I can't do this thing to myself every time I face fractions... although I do understand fractions... I don't know why...

Action tendency (behavioral/physiological). Case 1 developed various mechanisms in acting upon the appraisals that lead to an emotional generation of anxiety and fear over time; these included seeking help from a private tutor (in high school) and a propensity for preparing before a lecture or the practicum classes. In the case of the mathematics module that was subsequently taught online due to the pandemic, she/he mentioned:

I tried to make my own notes... I also tried before attending a lecture, the day before or during the weekend, to spend even a little time studying my notes in case I could find something that I can understand... because I felt that I was just mechanically writing down what he was telling us, without understanding what I was actually writing... and I was trying to devote even a little time to study...

Conscious awareness. Due to her/his experiences, Case 1 seems to have recognized from an early age the problems with mathematics and her inability to act upon them. For example, when asked to describe her/his relationship with mathematics, she/he answered:

My relationship... in primary school... let's just say it was mediocre... I wasn't doing badly, I just always felt at a disadvantage in that subject, compared to other subjects... I don't know why I felt that way... [...] then at university it was a necessary evil so to speak... the two compulsory courses in mathematics education... I attended them and I think it went fine... for the rest... [modules in theoretical mathematics] I faced many problems... because I felt that I couldn't understand a thing...

Overt behavior. It seems that Case 1's perception of not having control over the experienced LEs led her/him to gradually give up and distance herself from the process of learning mathematics or at least attempting to learn. While describing her learning trajectory in middle and high school, she mentioned:

In middle school this got worse, I didn't do well at all, in high school I had distanced myself, I didn't pay any attention at all, I pretended mathematics didn't exist because it caused me anxiety...

And added later about her/his middle school mathematics teacher:

I was noticing my teacher's indifference and this then automatically created me an indifference in mathematics... and since we only had fifteen subjects in middle school, I decided to deal only with the rest...

5.1.2 Emotion Generation Routes

During Case 1's formal education, several LEs took place: in elementary school, she/he had stress inducing experiences with a teacher who was asking from weak pupils to solve exercises on the blackboard and in middle school this got worse with the indifferent teacher who didn't "explain anything". As a consequence, Case 1 didn't do well at all and in high school she/he had completely distanced her/himself, didn't pay attention and acted as if mathematics didn't exist because it generated anxiety. According to the SPAARS model, these school-related LEs had initially been appraised at the schematic level where active processing and interpretation of the LEs, concerning Case 1's goals, was taking place and the student started experiencing fear and anxiety ("the teacher kept asking pupils to stand in front of the class..." the teacher was "...never explained properly the concepts or the theory or taught us anything..." "I was very anxious, to be there exactly at 8:30 am..." "...didn't understand a thing..." "...I couldn't remember a thing...").

After several repetitions of similar LEs throughout the school years, gradually the generation of fear and anxiety through a schematic level of meaning became associatively driven and the emotions of fear and anxiety manifested themselves during the high school years, university, and in Case 1's practicum as if a parallel appraisal had occurred ("...this got worse, I didn't do well at all, in mathematics..." "I don't know why I can't do it..." "I feel too much anxiety..." "...especially too much anxiety with fractions... I think I can't do this thing to myself every time I face the fractions... although I do understand fractions... I don't know why..."). Case 1 is stuck in the emotion modules of anxiety and fear, latent schemata with information about danger and fear being activated, she/he interprets the school-related mathematics events in a distorted and biased way. In the presence of a stress-inducing event such as passing the mathematics exams at the university or teaching mathematics in the practicum, danger schemata get activated and the student is stuck within the distorted anxiety and fear-prone living. Here we have a direct, fast, automatic through the associative path emotion generation which leads to the repetition of the event-emotion binary relation. The student, because she/he had many gaps in mathematics at all educational levels, completely dissociates and acts as if the subject of mathematics does not exist ("...I had distanced myself, I didn't pay attention at all, I pretended they didn't exist because it caused me anxiety ..."). The student tries to maintain the negative experience separate from the self with the help of the inhibitory process and attempts to maintain the experience in a dissociated state to protect her/himself and the completion of important goals. The use by the student of the defense mechanism of dissociation could be dysfunctional and is a type of inhibition.

5.2 Case 2

Case 2, aged 21, was in the fourth year of her/his studies when interviewed and had successfully attended three compulsory modules in mathematics. She/he had completed the first part of the practicum and was currently attending the second. Some of Case 2's accounts included traumatic events that occurred early in childhood. Case 2's teachers' attitudes along with Case 2's inadequacies in mathematics created a self-fulfilling prophecy that led to abandoning any attempt in attending to the gaps. As a consequence of the constant anxiety and fear experienced, Case 2 began to show physical symptoms of headache and stomachache. Subsequently, to survive she/he completely ignored the subject of mathematics.

5.2.1 Components of the Affective process

Life events. During the interview, Case 2 described specific events that took place during the primary school years, at middle school, high school and at the university. One of case's earliest LEs with mathematics involved her elementary school teacher during the third grade; Case 2 characterized the teacher as being "a very bad teacher, one of the worst" and recalled an incident from the mathematics class:

I remember very distinctly, that... we were doing mathematics and... the teacher wanted to call someone on the blackboard and... somehow my name was mentioned... and he said... "there's no chance Case 2 would want to come and solve the problem" something like that, about mathematics, that I wasn't good at mathematics and he added... "and even if she/he gets up, do you think she/he'll be able to solve it?" something like that, I'm sure, I remember that very well...

In middle school, Case 2 mentioned another episode involving a mathematics teacher. His teaching approach entailed assessing students verbally by inviting them on the blackboard. Initially, the teacher was calling all students in an alphabetical order but after a while, since many students were not able to answer his questions, he started addressing to students who could solve an exercise:

I remember it was Geometry and... I was trying to draw perpendicular lines? Parallel, I think they were parallel lines... and I didn't know how to handle the set square [gnomon] and he didn't help me, he didn't show me, you know "hold it like this, do this"

he didn't help me at all and he just said "ok sit down" and... yes, since then he asked me two or three more times and saw that I was struggling and after a while he stopped calling students in turn and selectively said "who wants to get up on the board?" [...] in general, in middle school I didn't deal much with Mathematics...

At the university, Case 2 attended three modules in mathematics education and despite having a fear of mathematics, the lecturer's approach helped her/him to have a trouble-free experience. However, when asked about the experience with other modules whose content was purely mathematical, she/he alluded to the mathematics lecturer's teaching methodology:

Not a good experience in all respects... the guy [lecturer] had taken it for granted that undergraduates know everything about mathematics... He was just presenting stuff... he was teaching without taking into account that many undergraduates do not have the required background knowledge and thus could not understand a thing of what he was saying...

Interpretations. Case 2's interpretation of past and current LEs resulted in having the belief that she/he is "bad" at mathematics, creating a self-fulfilling prophecy that she/he would never be able to properly learn mathematics. While recalling events from childhood, Case 2 was asked if she/he could explain the primary teachers' pedagogical approach. In an attempt to illuminate their behavior, Case 2 referred to their fixation on just completing the curriculum:

they just wanted to cover the mathematics curriculum, all they cared about was "doing my work", nothing more, "not dealing with kids who face difficulties", that's all they cared about, to be formal in their teaching and nothing more... I think they generally didn't have the skills to deal with... let's say with... differentiating their teaching, to do something more for the children who generally faced some difficulties... and... a more general explanation... they were bad teachers they shouldn't be in school, these ones for sure ...

Also, while contemplating the overall experience throughout education, she/he mentioned:

Sometimes, some teachers tried to help me without any result and success because... many times I remember myself, and I realized this later that, the truth is that...that... they tried to help me but the truth is they were tired of dealing [with me] and so a 100% self-fulfilling prophecy was created for me, I couldn't deal, I told myself that I'm not good at mathematics, that the teachers are tired of dealing with me and... I stopped doing mathematics too, telling myself that I'm not good... in primary school I had a lot of knowledge gaps... and certainly in the middle and high school, the situation was an absolute mess...

Appraisals. Most of Case 2's experiences with mathematics were appraised as a threat to her/his goals of being good with all subjects, passing a mathematics module, and obtaining a bachelor's degree. For example, while remembering the kind of emotions evoked by the incident with the elementary school teacher in the third grade, she/he mentioned feeling stigmatized; when asked to elaborate more on this Case 2 replied:

He stigmatized me in the sense that... I felt bad about myself, that I'm not good, I felt like he was telling me that I am nothing... while in other subjects I was very good, I was a very good student in general, just in mathematics I had a problem and in other sciences such as physics and chemistry... [sighs]I felt like... I think it [the incident] stigmatized me from the point of view that I stopped doing mathematics in general and this created gaps that I was never able to cover... and it was something that was done in front of the whole class, it was a very bad experience...

Physiological changes. Since childhood, Case 2 felt a constant fear and anxiety every time she/he encountered mathematics. While discussing the emotions felt after the teacher in the third-grade mocked Case 2 about her/his inability to solve a problem, she/he indicated:

I definitely felt all eyes on me, I felt ashamed... disappointed... I felt a confusion in my mind for sure... that my legs were kind of cut off, that he said that, my name was mentioned in front of the whole class and... the teacher didn't do anything to help me and he said this... which is very serious and can stigmatize a child, it has stigmatized me! and I really don't know what else I can say...

Case 2 also acknowledged having experienced physical symptoms while or after having gone through a traumatic experience; the somatization of fear and anxiety for mathematics took the form of a headache or a stomachache. Early in the interview, when asked to describe the relationship with mathematics she/he mentioned:

I had a terrible anxiety... about school and... sometimes I remember getting headaches too, from the point of view that... they [my teachers] will ask me something in mathematics that I don't know... and I won't be able to answer...

Action tendency. In dealing with fear and anxiety about mathematics, Case 2 developed a propensity for action that incorporated resourcing help from a private tutor (in high school) or studying hard during the practicum. In the case of the former, Case 2 mentioned devoting extra time to learn from a private tutor, trying to compensate for the lack of prior knowledge in mathematics:

My teacher at the tutoring school, he was trying to help me... I would go to the tutoring school and he would give me, apart from the exercises given to the rest of the class, he would give me a lot of extra exercises in order to practice...

While discussing about the practicum, Case 2 mentioned her/his approach in preparing the lesson plans for her/his classes:

We had a week to prepare basically, to prepare three lessons, and I remember myself constantly studying mathematics...I was constantly studying mathematics in case the children ask me something...

Conscious awareness. Case 2 acknowledged several times the issues she/he faced with mathematics while being a student and an undergraduate. Case 2's awareness of the situation and particularly her/his inability to face and solve the problems with mathematics seems to have been crystalized in her/his approach of deliberately postponing exams for the mathematics modules she/he was attaining:

I also remember that both times, I left mathematics for the September [exam period] for some reason... I didn't even sit in that normal?? exam period and I left it for September, with the intention... well to have more time to study it... [...] I chose to study the module I knew best [non-mathematics related] and leave mathematics for September... yes... I don't know why or... I also had a fear here as well, yes, my fear again...

Overt behavior. From the interview with Case 2, it was apparent that her/his traumatic experiences - especially in elementary school- influenced her behavior of being disengaged during a mathematics class. This created many obstacles and eventually she/he gave up after a certain point. While asked what happened after the incident experienced in the third grade, Case 2 replied:

It got worse... after that I generally stopped doing mathematics and I stopped being in general... I stopped participating in... in all classes... in many core subjects because of this...

5.2.2 Emotion Generation Routes

Based on Case 2's account, her/his teachers' constant and consistent perception of her/his inability to solve mathematical problems as well as their discouraging attitude of actively engaging in the learning process, lead to the internalization of these beliefs and thus, created a self-fulfilling prophecy (...“there's no chance Case 2 would want to come and solve the problem on the blackboard”, “and even if she/he gets up, do you think she/he'll be able to solve it?”, “...I told myself that I'm not good at mathematics, that the teachers are tired of dealing with me...”). The emotions of anxiety and fear were initially schematically generated by the elementary teacher's attitude (“...I felt ashamed... disappointed... I felt confusion in my mind for sure... that my legs were kind of cut off...”) however, as years were passing by and these attitudes were not changing, eventually emotions became associatively generated (“I had a terrible anxiety... about school and... sometimes I remember getting headaches too...”). For Case 2 to survive, she/he distanced the self from anything related to mathematics (“It got worse... after that I generally stopped doing mathematics”). Difficulty to process fear and anxiety led to physical symptoms becoming the focus rather than the emotions that Case 2 becomes excessively worried about. Anxiety and fear affected the body systems, which lead to headaches and stomach ache. When Case 2 becomes anxious and fearful, her/his fight-or-flight response kicks into gear, releasing chemicals that can cause tension and pain in the body. The inhibition process facilitated the somatization of anxiety and fear.

5.3 Case 3

Case 3, aged 21, was in the fourth year of her/his studies when interviewed and had successfully attended four compulsory modules in mathematics. Case 3 had completed the first part of the practicum and was currently taking the second. From our discussion, it appeared that she/he had experienced various distressing events and that these experiences had an impact on Case 3's emotions and how she/he believed that these experiences would shape her/his future of teaching mathematics. The emotions of anxiety and fear were generated and there was activation of the sympathetic nervous system with symptoms of stomach pain and sweating. There was an apparent fear of not completing the goal related to successfully teaching mathematics during the practicum and passing the mathematics modules or obtaining her/his bachelor's degree. To prevent the above fears from happening, Case 3 undertook tutoring, studied related material and lecture notes, and, prepared intensively for the teaching duties during the practicum.

5.3.1 Components of the Affective process

Life events. Case 3's narrative included events that took place primarily during primary school and her/his time at university. When asked whether she/he could remember any specific incidents from school, she/he instantly recalled an event with her/his elementary teacher:

...in the fifth grade we were doing fractions, I didn't understand them and I had made some mistakes in the exercises... while the teacher was checking our solutions, she threw my notebook at me from her desk... and told me that I'm unacceptable because she has covered this topic so many times and I should be ashamed...

At the university, Case 3 faced issues with a module that was oriented towards the theoretical side of mathematics and failed to pass the exams three times. Case 3 referred to the overall experience by recalling her/his state of understanding and the lecturer's pedagogical approach:

...in the lecture hall I didn't understand a thing, nothing... and if I had questions... the lecturer would answer that "this is a university, we are not an elementary school to answer your questions..."

Interpretations. Case 3's interpretation of past LEs resulted in developing the belief that she/he will not be able to properly teach a mathematics lesson because she/he will not be in a position to either understand the students' questions or answer them correctly. While recalling a specific day from last year's practicum, she/he shared her/his thoughts during that day but also expressed her/his fears for the class that was due the day after the interview:

...basically... I was just thinking that... that I won't be able to see the mistake and I won't... I won't understand... what the children are actually telling me... for example, tomorrow I have to teach mathematics... uh... it's my worst... I feel that... I won't understand what they'll ask me... and that... if they ask me something that is, let's say, from a previous lesson that I haven't prepared to teach... I won't know how to answer...

Appraisals. Case 3's appraisal of the events related to mathematics actually is the processing of the interpretation: Case 3 considered these events as threats to the goals of successfully teaching mathematics during the practicum, passing a mathematics module, or getting her/his degree. When asked whether the experiences at the university changed her/his attitude toward mathematics she/he replied:

...I have not seen it differently at all... the same opinion I had about mathematics since elementary school, I still have now...

Physiological changes. Since elementary school, Case 3 had developed a constant anxiety for every activity entailing mathematics. When the teacher in the fifth grade threw the notebook and embarrassed Case 3, she/he burst into tears:

...of course, I started crying afterwards... and from then on it was even worse... I don't remember any other incidents...

During the first mathematics class in the first-year practicum, the activation of Case 3's emotional system associated with fear and anxiety was the result of Case 3's physiological response that made her/his almost faint:

...the first time I taught mathematics... I noticed that... everyone basically noticed... the pupils, my supervisor... and my fellow students... that... I almost fainted... I had a lot of anxiety even though... the topic I had to teach was not difficult... but... just thinking that I had to teach mathematics... I had... I had a completely... a completely different feeling than in the other subjects I have previously taught...

The change in Case 3's behavior and physiology were also noticed by her/his fellow students:

During that lesson... the undergraduates from my group were also in the class, at first, they thought something else was wrong with me... and... they came and said "Are you okay? Is there something wrong with you? [...] I said "I'm fine" and they replied "But you are pale... it seems that you are not well!"

While further elaborating on Case 3's response and thoughts, added:

I had a constant anxiety... a stomach ache... [...] I basically feel like it's never going to go away... I just... come to terms with it... it's an anxiety I've always had so... I've never lived without it I think... ever since I can remember myself with mathematics... this is my permanent situation, so I can't... think about how I will be without it...

Action tendency. Case 3's actions in attending to her/his issues with mathematics, materialized in the form of private tutoring, studying and carefully preparing for teaching classes. After describing the incident with the fifth-grade teacher, she/he added more details about the attempts to understand fractions:

...but even now... that I have [to teach at the] fifth grade in my practicum... I still don't know these things [fractions] well... I never could... while I also study them later... to understand them, I still can't... I feel that I have gaps...

Conscious awareness. Throughout the interview, Case 3 recognized her/his fear and anxiety about mathematics. Mentioned several times experiencing shame and being incapable of "filling her/his knowledge gaps" in mathematics. At the beginning of the interview, when asked to describe her/his relationship with mathematics, she/he replied:

From primary school I didn't have a good relationship with mathematics at all... I was afraid of it... but I was afraid of it because all my teachers treated me as if I didn't know anything... and then I was coming home and I had to study... obviously... and I had a lot of pressure from my family that I absolutely had to understand mathematics... and my experience was horrible...

Overt behavior. Case 3's behavior manifested in the form of a shock experience: when the elementary teacher embarrassed Case 3, she/he immediately started crying ("I started crying afterwards") and then had to face for the first time the fears during the practicum, she/he became pale and nearly passed out ("I almost fainted...").

5.3.2 Emotion Generation Routes

During Case 3's childhood, the teacher's tendency to yell at her/him had initially been appraised at the schematic level, and the student had experienced fear; Case 3 could never know how the teacher would react next time. After several repetitions of similar events, the generation of fear through a schematic level of meaning gradually became associatively driven. The emotion of fear manifests itself at the university and the practicum as if a parallel appraisal had occurred. The classroom or exam room is perceived and recognized through analogical visual representations. Information from this level is transferred to the propositional level, where knowledge for

studying mathematics or teaching mathematics during the practicum is activated. Representations at the propositional level are explicit, distinct and abstract including beliefs, ideas, objects and concepts and their relationships.

Worry takes the form of repeated anxiety related to an undesired outcome that could occur in the future and that could be realistic or unrealistic. Complexity is added to the basic emotions of fear and anxiety through additional cognitive information resulting in the experience of constant anxiety and fear about events that will be experienced in the present and the future. Thus, a sequence of new appraisals takes place as more information becomes available to Case 3. We consider the interaction between events, their analogical representation, and propositional information as an interpretation. The interpretation of the event “the lecturer sets difficult exam questions” relates to some of the student's goals, such as passing the course and practicum to get a degree and all of the goals included in the goal of personal achievement.

As we have already stated, appraisal is the elaboration of an interpretation (e.g., I will make mistakes while teaching mathematics in class) concerning the individual's current goal structure (e.g., pass the course, complete the practicum) at the schematic level of meaning. The relationship between the interpretation and the structure of the existing goal determines which emotion will be generated e.g., if the interpretation is that the accomplishment of important goals is threatened, a threat appraisal occurs at the schematic level and the person begins to feel fear.

“I will fail the exam” is appraised concerning her existing goal structure at the schematic level. This interpretation means that the achievement of the goal of personal survival is at risk and a threat appraisal is an outcome. Threat appraisal serves to activate the fear-related ANS and leads to an action tendency. The combined awareness of threat appraisal and physiological changes constitute the experience of fear.

According to the SPAARS model, Case 3's behavior could be explained by assuming that, as a child, she/he had developed schematic models where she/he saw the self as a failure and that she/he was never/ would never become good enough at mathematics. Later, as Case 3 grew older, she/he developed healthier models that focused on growing self-confidence – the old models were inhibited; but when events got involved with the old inhibited models, then those models were reactivated and dominated the system.

6. Discussion and conclusions

To investigate LEs and emotion generation in academic settings we applied the SPAARS cognitive model with the two routes for emotion generation, the schematic and the associative route. The first route, via the schematic level, has been recorded in other appraisal theories of emotion (Arnold, 1960; Lazarus, 1991, 2001). The second route, via the associative level, is direct, automatic, deriving from the constant coupling of the event – emotion that happened in the past and stored in autobiographical memory. The repetition overcomes the appraisal of the LE experienced in the now and current LE becomes associated with the emotion experienced in the past. The model overall provided a sophisticated explanation of the development of emotional order and disorder, is multi-level (analogical, schematic, propositional, associative) with the process of appraisal taking place at the schematic level.

The three cases we present described experiences related to mathematics they had felt to be negative in childhood and young adulthood. These included events less obviously traumatic, yet distressing for them. It appeared from their discussions that these early experiences often had an impact on the participant's experience of emotions and how they believed that these experiences would shape future emotional expression if they encounter similar situations

The data presented showed a high level of emotional distress, with all three participants, experiencing fear and anxiety. The interviews pointed out that emotion in childhood and adolescence shaped the emotion generation in young adulthood through the activation of the associative route of SPAARS. It became apparent that childhood experiences perceived as threatening in relation to mathematics led to the generation of negative emotions (e.g., teacher shouting) in tertiary education. Goals and plans played an important role in the way the LEs related to mathematics were appraised by the three students and for the emotions that are generated. The extent to which they are achievable or not, realistic or not defined whether the students experienced positive or negative emotions.

The three participants were asked to describe LEs related to mathematics and they spontaneously recalled from their autobiographical memory concerning the academic setting and the emotions accompanying them. When discussing past experiences, they described how they faced emotionally difficult periods in their lives alongside more general views of emotions within academic institutions. A common theme in the data concerned the role teachers/lecturers in elementary school/university and their pedagogical approach played in the

generation of emotions. Indeed, it was discussed in the interviews how the students felt and explicitly stated that their teacher/lecturer was “bad at teaching”. It was highlighted how teachers' distress and anxiety was often key factor in the expression of their own negative emotions. According to students' appraisals, teachers were distressed because they could not understand mathematics themselves or they were indifferent or they were not investing in their teaching.

Within this study, the participants discussed how they tried to keep the experienced LEs and the attached emotions distant from themselves with dissociation in an attempt to maintain the experience in a dissociated state to protect the self and the completion of important goals. The use of the defense mechanism of dissociation could be dysfunctional in cases like that. As they said after certain point mathematics didn't exist for them to minimize their anxiety. The three students also gave information about the potential somatization of emotions, and discussed how fear and anxiety often led to body tension, stomach ache, headache, and fainting. These findings are in accordance with Coggins and Fox (2009) finding were participants in their study used dissociation as a strategy to separate their emotion from their sense of self and gave information about somatization of emotions.

The researchers thought that this is an area where qualitative methodology could be particularly useful in developing a more in-depth understanding of the cognitive parameters that lead to the development of emotions. The appraisal of early experiences of emotions in childhood appeared to be of key developmental importance. The participants described a significant negative event in their past which appeared to have affected their emotional development.

We aimed to show a different way to analyze the LEs experienced by students based on the seven key components (LEs, interpretation, appraisal, biological changes, action tendency, conscious awareness, and overt behavior) for emotion generation and to present an example of a research application of the SPAARS framework. We aimed at demonstrating that the SPAARS architecture is an efficient and flexible tool to be used in explaining emotion generation in educational settings. The concept of emotion is approached holistically and covers all seven components of its generation. Within the model, emotions derive through the cognitive process of appraisal or associatively when past LEs and their related emotions are stored in the emotional autobiographical memory. Important conclusions drawn from the study's results include the following:

- a) The adverse LEs related to mathematics encountered in childhood and adolescence are dynamic, unfolding and are affecting the ways undergraduates interpret the current mathematics-related life events
- b) The cognitive model of SPAARS with the two routes for emotion generation, schematic and associative, is a useful tool to be applied in explaining the emotion generation in the educational setting
- c) The concept of appraisal is more contemporary and relevant than ever in explaining the interaction of the individual and the environment.
- d) The holistic approach to emotion generation with the seven components for its generation appears to be effective in explaining the emotions generated in the educational settings.

The results from this study offer some useful theoretical insights into the development, process, and consequences of emotion generation. The findings are also relevant to teaching practices in academic environments and do need to be followed by further research. The authors are not aware of any other research in this area that has conducted that type of in-depth qualitative analysis of emotion generation by applying a cognitive model and it is argued that this study could increase our understanding of emotion generation within academic settings. As far as the social impact of this research project is concerned, given the increasing focus of policy makers and researchers on the role of all academic settings in the mental health of young people, we tried to record the extent to which variation in the mental health of young people could be explained by variables operating at the cognitive level. We focused on the importance of school and university-related LEs for the generation of emotion and on how the students interpret and appraise these events.

We hope that these results would lead to further research culminating in the implementation of prevention programs aimed at identifying early-stage high-risk students showing increased levels of anxiety and fear. These programs could have a positive impact in reducing anxious and fearful behaviors as well as preventing mental health problems later on in life. The academic setting is the ideal context to apply intervention programs to a large number of students before a disorder unfolds on full scale. Given the co-existence of early emotional disorders and academic difficulties, it's worth organizing and implementing holistic intervention programs that take into account both the factors related to the cognitive-emotional dimensions of academic settings. These programs could train students in coping with emotion and problem-solving strategies to face controllable and uncontrollable LEs and reduce the risk of experiencing negative emotions. Universities are suitable setting for delivering effective interventions to support well-being and prevent mental health problems.

Mental health provision in academic settings is highly valuable and has to be a policy focus in Greece, which traditionally has not had a strong education-based mental health service.

Our findings have important implications in relation to the design of initiatives aiming at alleviating the effects of undergraduates' negative LEs with mathematics. Current approaches focus on the development of courses for confronting mathematics anxiety (e.g., Ganley et al., 2019); constructing appropriate learning opportunities (e.g., McGlynn-Stewart, 2010); the establishment of mathematics support centers which aim at addressing issues surrounding the transition to university mathematics and to support undergraduates' learning of mathematics and statistics (e.g., Matthews et al., 2013) and; psychotherapy-based interventions (e.g., Ramirez & Beilock, 2011). In other words, such programs and courses concentrate their efforts on either providing training for coping with the emotional consequences of negative LEs with mathematics or on actively supporting the development of knowledge and competencies of undergraduates which face issues with mathematics. By incorporating the insights offered by this study's findings, the SPAARS model could act as an anchor for developing initiatives which aim at remedying both the cognitive as well as the emotional dimensions associated with undergraduates' learning of mathematics.

It is necessary to consider some limitations in this work. Our sample comprised of students only from one institution, thus limiting the possible generalization of the results to the overall university population. Therefore, future research should corroborate our results with university students from other geographical and cultural contexts. Additionally, since the majority of the ongoing LEs reported were academic in nature, participants may have been using certain appraisal processes that lead to emotion generation that are specific to academic stressors. Since the majority of participants in our study were females, we understand that this issue could be a potential line of future research. Another limitation might be the use of interviews as exclusive data collection method because it can lead to response bias. In future research, combining methodologies to include psychometric instruments and interviews would increase our understanding of students' appraisal of LEs and emotion generation related to mathematics. In spite of these limitations, our results advance our understanding of the LEs and the emotion generation in students in relation to mathematics in academic settings.

References

- Alder, B. (2005). (Ed. E. Vasilaki). *Motivation, Emotion and Stress*. Ellinika Grammata.
- Arnold, M. (1960). *Emotion and Personality* (2 vols.) New York: Columbia University Press.
- Busseri, M. A., & Sadava, S. W. (2011). A review of the tripartite structure of subjective well-being: Implications for conceptualization, operationalization, analysis, and synthesis. *Personality and social psychology review*, 15(3), 290-314.
- Carballo, J.J., Muñoz-Lorenzo L., Blasco-Fontecilla H., Lopez-Castroman J., García-Nieto R., Dervic K., Oquendo M.A., Baca García E. (2011). Continuity of depressive disorders from childhood and adolescence to adulthood: a naturalistic study in community mental health centers. *Prim Care Companion CNS Disord.* 13(5): PCC.11m01150. <https://doi.org/10.4088/PCC.11m01150>
- Coggins, J., & Fox, J. R. E. (2009). A qualitative exploration of emotional inhibition: A basic emotions and developmental perspective. *Clinical Psychology and Psychotherapy*, 16(1), 55-76. <https://doi.org/10.1002/cpp.604>
- Compas, B. E. (1987). Coping with stress during childhood and adolescence. *Psychological Bulletin*, 101(3), 393–403. <https://doi.org/10.1037/0033-2909.101.3.393>.
- Cleland, C., Kearns, A., Tannahill, C., & Ellaway, A. (2016). The impact of life events on adult physical and mental health and well-being: longitudinal analysis using the Go Well health and well-being survey. *BMC Research Notes*, 18;9 (1): 470. <https://doi.org/10.1186/s13104-016-2278-x>
- Dalgleish, T., Mathews, A., & Wood, J. (1999). Inhibition processes in cognition and emotion: A special case. In T. Dalgleish & M. J. Power (Eds.), *Handbook of cognition and emotion*. Chichester: Wiley.
- Dalgleish, T. (2004). Cognitive approaches to post traumatic stress disorder: The evolution of multi representational theorizing. *Psychological Bulletin*, 130, 2228-260.
- deLijster, J.M., van den Dries, M.A., van der Ende, J. et al. (2019). Developmental Trajectories of Anxiety and Depression Symptoms from Early to Middle Childhood: A Population-Based Cohort Study in the Netherlands. *J Abnorm Child Psychol* 47, 1785–1798. <https://doi.org/10.1007/s10802-019-00550-5>
- DeLongis, A., Folkman, S., & Lazarus, R. S. (1988). The impact of daily stress on health and mood: Psychological and social resources as mediators. *Journal of Personality and Social Psychology*, 54(3), 486–495. <https://doi.org/10.1037/0022-3514.54.3.486>.

- Diener, E., Pressman, S. D., Hunter, J., & Delgado-García, D. (2017). If, why, and when subjective well-being influences health, and future needed research. *Applied Psychology: Health and Well-Being*, 9(2), 133-167.
- Du Toit, S. A., Kade, S. A., Danielson, C. T., Schweizer, S., Han, J., Torok, M., & Wong, Q. J. (2020). The effect of emotional working memory training on emotional and cognitive outcomes in individuals with elevated social anxiety. *Journal of Affective Disorders*, 261, 76-83.
- Dwyer, L. A., Cummings, L. A. (2001). Stress, Self-Efficacy, Social Support, and Coping Strategies in University Students. *Canadian Journal of Counseling and Psychotherapy*, 35(3).
- Eligio, X. U. (2017). *Understanding Emotions in Mathematical Thinking and Learning*. Elsevier. <https://doi.org/10.1016/c2014-0-02036-9>.
- Elliot, C.H. & Lassen, M.K. (1997). A schema polarity model for case conceptualization, intervention and research. *Clinical Psychology: Science and Practice*, 4, 12-28.
- Folkman, S., & Lazarus, R.S. (1988). The relationship between coping and emotion: Implications for theory and research. *Social Science and Medicine*, 26, 309 – 317.
- Frijda, N. (1993). Appraisal and Beyond. *Cognition & Emotion*, 7 (3/4), 225 – 231.
- Ganley, C. M., Schoen, R. C., LaVenja, M., & Tazaz, A. M. (2019). The Construct Validation of the Math Anxiety Scale for Teachers. *AERA Open*, 5(1), 233285841983970. <https://doi.org/10.1177/2332858419839702>
- Hannula, M.S. (2020). Affect in Mathematics Education. In: Lerman, S. (Ed) *Encyclopedia of Mathematics Education*. Springer, Cham. https://doi.org/10.1007/978-3-030-15789-0_174.
- Hitchcock, C., Rees, C., Rodrigues, E., Gormley, S., Dritschel, B., & Dalgleish, T. (2019). Misremembrance of things past: Depression is associated with difficulties in the recollection of both specific and categorical autobiographical memories. *Clinical Psychological Science*. <http://doi.org/10.17605/OSF.IO/2F76R>.
- Hitchcock, C., Newby, J., Jarvis, E., Howard, R., Golden, A., Kuyken, W., & Dalgleish, T. (2020). Memory fluency, memory specificity, and the fading-affect bias for positive and negative autobiographical events in major depressive disorder: performance on a good day-bad day task. *Journal of Experimental Psychology: General* <http://dx.doi.org/10.1037/xge0000617>.
- Holmes, T. H., & Rahe, R. H. (1967). The Social Readjustment Rating Scale. *Journal of Psychosomatic Research*, 11(2), 213–218. [https://doi.org/10.1016/0022-3999\(67\)90010-4](https://doi.org/10.1016/0022-3999(67)90010-4)
- Kettlewell, N., Morris, W., R., Ho g, N., Cobb-Clark, D., Cripps, S., Glozier, N. (2020). The differential impact of major life events on cognitive and affective wellbeing, *SSM - Population Health*, Vol. 10, 100533.
- Lähdepuro, A., Savolainen, K., Lahti-Pulkkinen, M., Eriksson, J., Lahti, J., Tuovinen, S., Kajantie, E., Pesonen, A., Heinonen, K., & Räikkönen, K. (2019). The Impact of early Life stress on Anxiety symptoms in Late Adulthood, *Scientific Report*, www.nature.com/scientificreports/
- Lazarus, R.S., & Folkman, S. (1984). *Stress appraisal and coping*. New York: Springer.
- Lazarus, R., S. (1991). *Emotion and Adaptation*. New York: Oxford University Press.
- Lazarus, R., S. (2001). Relational meaning and discrete emotions. In K.R. Scherer, A. Schorr & T. Johnson (Eds.) *Appraisal processes in emotion: Theory, methods, research*. Oxford: Oxford University Press.
- Lewis, M.D., & Granic, I. (1999). Self-organization of cognition - emotion interaction. In T. Dalgleish, M. J. Power (Eds.). *Handbook of cognition and emotion*. Chichester: Wiley.
- Luhmann, M., Hofmann, W., Eid, M., Lucas, R. E. (2012). Subjective well-being and adaptation to life events: A meta-analysis. *Journal of Personality and Social Psychology*, 102(3), 592–615. <https://doi.org/10.1037/a0025948>.
- Margalit, M. (2003). Resilience Model Among Individuals with Learning Disabilities: Proximal and Distal Influences. *Learning Disabilities. Research & Practice*, 18, 82–86.
- Matthews, J., Croft, T., Lawson, D., & Waller, D. (2013). Evaluation of mathematics support centres: a literature review. *Teaching Mathematics and its Applications*, 32(4), 173-190. <https://doi.org/10.1093/teamat/hrt013>
- McGlynn-Stewart, M. (2010). Listening to Students, Listening to Myself: Addressing pre-service teachers' fears of mathematics and teaching mathematics, *Studying Teacher Education*, 6:2, 175-186. <https://doi.org/10.1080/17425964.2010.495898>
- Moors, A. (2010). Automatic constructive appraisal as a candidate cause of emotion. *Emotion Review*, 2, 139-156.
- Nerdrum, P., Rusten, T., & Helge Ronnestad, M. (2009). Psychological Distress Among Nursing, Physiotherapy and Occupational Therapy Students: A Longitudinal and Predictive Study. *Scandinavian Journal of Educational Research*, 53(4), 363-378. <https://doi.org/10.1080/00313830903043133>.
- Oatley, K., & Johnson-Laird, P., N. (1987). Towards a cognitive theory of emotions. *Cognition and Emotion*, 1, 29-50.
- Oatley, K. (1992). *Best laid schemes: The psychology of Emotion*. Cambridge: Cambridge University Press.

- Oatley, K., & Duncan, E. (1992). Incidents of emotion in daily life. In K.T. Strongman (Ed.), *International review of studies on emotion* (vol.2). Chichester: Wiley.
- Pekrum, R., & Stephens, E.J. (2010). Achievement emotions: a control value approach. *Soc Personal Psychol Compass* 4: 238-255
- Power, M.J., & Dalgleish, T. (1999). Two routes to emotion: Some implications of multilevel theories of emotion for therapeutic practice. *Behavioural and Cognitive Psychotherapy*, 27, 129-141.
- Power, M., & Dalgleish, T. (2020) (Ed. E. Vasilaki). *Cognitive Processes and Emotions. From order to Disorder*. Gutenberg
- Ramirez, G., & Beilock, S. L. (2011). Writing about testing worries boosts exam performance in the classroom. *Science*, 331(6014), 211-213. <https://doi.org/10.1126/science.1199427>
- Rappo, G., Alesi, M., Pepi, A. (2017) The effects of school anxiety on self-esteem and self-handicapping in pupils attending primary school, *European Journal of Developmental Psychology*, 14:4, 465-476. <https://doi.org/10.1080/17405629.2016.1239578>
- Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology*, 19(6), 551-554. <https://doi.org/10.1037/h0033456>
- Roeser, R. W., Eccles, J. S., & Sameroff, A. J. (1998). Academic and emotional functioning in early adolescence: Longitudinal relations, patterns, and prediction by experience in middle school. *Development and Psychopathology*, 10(2), 321–352. <https://doi.org/10.1017/S0954579498001631>
- Scherer, K.R. (2001). Appraisal considered as a process of multilevel sequential checking. In K.R. Scherer, A., Schorr & T. Johnstone (Eds.). *Appraisal processes in emotion: Theory, methods, research*. Oxford: Oxford University Press
- Schimmack, U. (2008). The structure of subjective well-being. In M. Eid & R. J. Larsen (Eds.), *The science of subjective well-being* (pp. 97–123). The Guilford Press.
- Schreier, M. (2014). *Qualitative Content Analysis*. In U. Flick (Ed.), *The SAGE Handbook of Qualitative Data Analysis* (pp. 170-183). SAGE
- Semplonius, T., & Willoughby, T. (2019). A person-centered analysis of sleep and emotion dysregulation: Short- and long-term links with depression and alcohol use. *Journal of American College Health*, 67(5), 486-496. <https://doi.org/10.1080/07448481.2018.1497637>
- Sheldon, E., Simmonds-Buckley, M., Bone, C., Mascarenhas, T., Chan, N., Wincott, M., Gleeson, H., Sow, K., Hind, D., & Barkham, M. (2021). Prevalence and risk factors for mental health problems in university undergraduate students: A systematic review with meta-analysis. *Journal of Affective Disorders*, 287, 282-292. <https://doi.org/10.1016/j.jad.2021.03.054>.
- Silva, V., Costa, P., Pereira, I., Faria, R., Salgueira, A. P., Costa, M. J., Sousa, N., Cerqueira, J. J., & Morgado, P. (2017). Depression in medical students: insights from a longitudinal study. *BMC Medical Education*, 17(1), 184. <https://doi.org/10.1186/s12909-017-1006-0>.
- Smith, C., Lazarus, R. (1993). Appraisal Components, Core Relational Themes, and the Emotions. *Cognition & Emotion*, 7 (3/4), 233 – 269.
- Uijtdewilligen, L., Singh, A., Chinapaw, M., Koppes, L., Willem van Mechelen, W., & Twisk, J. *BMC Public Health* (2014). Number and appraisal of daily hassles and life events in young adulthood: the association with physical activity and screen time: a longitudinal cohort study, *BMC Public Health*, volume 14 Article number: 1067.
- Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods* (6th ed.). Thousand Oaks, CA: Sage