Educ Psychol Rev (2006) 18:361–376
DOI 10.1007/s10648-006-9031-2

ORIGINAL ARTICLE

Focusing on the Complexity of Emotion Issues in Academic Learning: A Dynamical Component Systems Approach

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Published online: 3 November 2006

Abstract Understanding the interrelations among students' cognitive, emotional, motivational, and volitional processes is an emergening focus in educational psychology. A dynamical, component systems theory of emotions is presented as a promising framework to further unravel these complex interrelations. This framework considers emotions to be a process that is composed of cognitive, neurophysiological, motor expression, and motivational processes—as well as feelings—that mutually regulate each other over time and within a particular context. This comprehensive view of emotions provides a more complete understanding of the social and dynamical nature of emotions and the integration of emotions within learning processes. Using a dynamical, component systems view of emotional processes, interrelated with learning processes, involves a shift in research methodologies and instruments to adequately investigate the role(s) of emotions within learning contexts. But more importantly, it may provide a powerful framework that can clearly show teachers and parents the role(s) that emotions play in students' acquisition of knowledge and skills.

Keywords Emotion · Learning · Dynamical component systems

Introduction

As this special edition demonstrates, understanding the interrelations among students' cognitive, emotional, and motivational processes is an emerging focus of educational psychology research. Our own research into these processes has led us to another emerging field of psychology research, that of dynamical systems theories. In this paper, we will

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integrate these two emerging fields of research and theory to demonstrate the usefulness that this synthesis provides to others who are interested in investigating the complex processes that occur within students' on-going learning endeavors.

In line with socio-constructivist accounts of learning (see Cobb & Bowers, 1999; Greeno, Collins, & Resnick, 1996), we perceive students' learning behaviors not only to be highly situated but also to be fundamentally constituted by interactions among (meta)cognitive, conative, and affective processes (Op 't Eynde, De Corte, & Verschaffel, 2001). From such a perspective, students' affective processes (e.g., moods or emotions) are no longer treated as the positive or negative side-effects of learning. On the contrary, they are conceived as an integral part of learning in close interaction with conative and cognitive processes. Thus, at a conceptual level, we distinguish between the three traditionally acknowledged modes of mental functioning: cognition, conation, and affection (see Hilgard, 1980; Snow, Corno, & Jackson, 1996). While there is a broad consensus that cognition refers to cognitive and metacognitive aptitudes[1] and processes, and conation includes motivational and volitional aptitudes and processes, a clear definition of affection or affective processes is lacking. English and English (1958) defined affect as:

> "A class name for feeling, emotion, mood, temperament...a single feeling-response to a particular object or idea....the general reaction toward something liked or disliked... the dynamic or essential quality of an emotion; the energy of an emotion."(p. 15)

Currently, there is some common, almost intuitive, understanding that the distinctive features of affect have to do with energy or emotional feelings, but even in recent state-of-the-art publications like, for example, the *Handbook of Affective Sciences* (Davidson, Scherer, & Goldsmith, 2003), a more elaborated shared definition seems absent. Rather, scholars tend to concentrate their research efforts on defining and investigating specific aptitudes and/or processes that are subsumed under the class name "affect". In their introduction to the *Handbook of Affective Sciences*, Davidson *et al.* (2003) identified six most frequently studied affective phenomena: emotions, feelings, moods, attitudes, affective styles, and temperaments. Typically, scholars conduct "mood research", "emotion research" or "research on attitudes", etc. Possibly, a growing understanding in these respective research domains regarding the characteristics of the specific phenomena and processes under investigation, combined with insights from the rapidly developing field of neurophysiological research (see e.g., Panksepp, 2004) might in time lead to a more detailed and solid definition of the typical characteristics of the whole class, i.e., affect. For our part, we have mainly focused on emotions, and more specifically the role(s) of emotions, within learning episodes (e.g., Op 't Eynde, De Corte, & Verschaffel, in press a, b; Turner & Schallert, 2001). In these lines of research, "emotion" is referred to as a relatively brief episode of coordinated brain, autonomic, and behavioral changes that facilitate a response to an external or internal event of significance for the learner (see Davidson *et al.,* 2003, p. xiii).

In this article, we will particularly address aspects related to the interactions among emotional–conative–cognitive processes, explain how these processes are integrated with learning processes, and explore how educators and educational psychologists may use this information to facilitate, and further explore, students' learning. We believe that Dynamical Systems theories (Kelso, 1995; Kugler & Turvey, 1987; Mascolo, Harkins & Harakal, 2000; Waugh, 2002) allow us to further clarify the complex interrelationships of students'

[1] The term "aptitudes" is used here as a general term that refers to individual difference constructs that are respectively cognitive, conative, or affective in nature and in interaction with the context determine students' problem-solving behaviour (see e.g., aptitude-treatment interaction, Snow *et al.,* 1996).

emotions, cognitions, motivations, and volitional processes within school learning. Such an approach of emotions within learning contexts addresses and integrates diverse aspects such as the influence of social contexts (e.g., particular courses, teachers, and peers) as well as students' internal traits (e.g., mastery-oriented or performance-oriented), states (e.g., fatigue, anxiety, self-confidence), and processes (e.g., problem-solving, self-regulation). More specifically, we argue that holding a perspective on emotions as processes composed of multiple component systems that mutually regulate each other over time and within a particular learning context (i.e., a dynamical systems account of emotions) pushes educational research to a more detailed understanding of what constitutes emotions and the intricate relationship emotions have with cognitive and conative processes. Hence, we make the case that underneath the, at first sight predominantly cognitive nature of learning, emotional as well conative processes are very much present and co-directing the learning process. This line of research should enable teachers to become more aware of the various ways in which emotions are present in students' learning in order to adequately organize their instruction and scaffold students' learning processes.

Dynamical, Component Systems Frameworks of Emotions

Inspired by the impact and the success of dynamical systems theory (DST) in a number of sciences, several scholars have explored the adequacy of such an approach to come to a better understanding of the nature of emotions (see e.g., Lewis & Granic, 2000). In particular, emotion-focused theorists and researchers have suggested that, when investigating emotions, one should draw from the extant knowledge base that has been conducted in the psychology of emotions. Current emotion theory and research has been struggling with a conceptualization of emotions that addresses (see Scherer, 2000):

(a) *both* the phenomenological distinctiveness and the intricate interweaving of cognition and emotion,
(b) *both* the dynamic nature of emotional processes and the existence of steady states that can be labeled with discrete terms (e.g., anger, happy, proud),
(c) *both* the psychobiological nature of emotion and its cultural constitution.

Attempting to consolidate and understand these issues, theorists have turned to dynamical systems frameworks because these frameworks integrate both micro- and macro- processes. Hence, these frameworks provide understanding of moment-to-moment processes as well as recurring patterns.

Principles of Dynamical Systems

One of the hallmarks of a dynamical system is that the system itself contains multiple subsystems or *component systems*. These component systems interact in a specific context through bidirectional feedback processes that enable the components to continually adjust and coordinate with each other. While adjusting to each other, each component system is also sensitive to contextual information. The components' sensitivity to both internal and external information, as well as the bidirectional feedback network, brings about on-going reorganization and adaptation. In relation to emotions, Mascolo *et al.* (2000) identified four basic dynamical principles in their "*component systems approach to emotional development*" framework (p. 127):

1. Emotional states and experiences are composed of *multiple component processes*;

2. Emotional experiences emerge through the *mutual regulation* of component systems over time and within particular contexts;
3. Component systems are *context sensitive*, meaning they not only adjust themselves to each other but also to continuous changes in the social context;
4. As such, emotional experiences *self-organize* into a series of more or less stable patterns or *attractors* that yield a large number of minor variations.

Because these principles provide a coherent, yet relatively succinct framework for understanding complex emotional processes, we will now explain and elaborate each of these principles with respect to students' emotions within learning contexts.

Emotions as Composed of Multiple Component Systems

Mascolo *et al.*'s (2000) first principle of DST is that "emotional states and experiences are composed of multiple component processes" (p. 127). Providing additional depth to the description of component systems, Scherer (2004, p. 138) identified five interacting components involved in emotional processes: (1) the cognitive component, which is responsible for the evaluation of objects and events, (2) the neurophysiological component, which regulates arousal, (3) the motor expression component, which enacts emotional expression and reaction, (4) the motivational component, which prepares and directs action, and (5) the subjective feeling component, which monitors the internal state and the interaction with the immediate context.

In "normal" circumstances these components function relatively independently from each other. For example, take a student, "Fran", who has to read a novel and write a paper on it for homework in the evening. Fran can read the novel without having specific feelings or a specific expression on her face that is related to her experience of reading. However, as soon as she realizes that it is getting late and there are still too many pages to be read before she can start to write her paper, the different components start to function in an interrelated manner. Her interpretation and appraisal of the situation (cognitive) initiates arousal as well as a specific expression on her face of stress, perhaps anxiety, which is accompanied by a specific subjective feeling that creates an action tendency to quicken her reading or skip some pages. The interdependent and interrelated functioning of these components, and the certain degree of synchronization that comes with it, fundamentally characterize Fran's emotional experience. The interdependent and interrelated functioning of component systems is the necessary condition for the occurrence of an emotional experience.

Hence, all component systems are essential parts of an emotional experience. The cognitive component relies on an individual's intake, processing, and evaluation of informational cues that are provided during his or her interaction with the environment. The appraisal process, in itself, involves complex cognitive processing such as decoding current contextual input and comparing the information with personal expectations and goals. Indeed, the appraisal process is characterized by an evaluation of the situation alongside five dimensions: novelty, pleasantness, goal significance (value), coping potential (control), and norm compatibility (see Ellsworth & Scherer, 2003). Taking into account the variety and complexity of event-related inputs and a person's multiple goals and motives involved at any time, initial appraisal processes imply the subconscious monitoring of the relationships among all the different sensory changes and the person's goals (Mascolo *et al.,* 2000). Reading her novel at home, one can imagine a number of elements in the situation that might, at least at a subconscious level, attract Fran's attention. However, because she (1) values finishing her homework and (2) at a certain point, develops an

appraisal that she is losing control of the situation and might not be able to finish her homework, the stage has been set for Fran's experience of an unpleasant emotion, such as stress or anxiety.

These initial (to some extent subconscious) appraisal processes mutually engage the neurophysiological component (including hormonal processes) as well as the motor expression and motivational component that are responsible for facial, kinesthetic, and vocal expressions along with felt action tendencies. Changes in these component systems provide immediate feedback to the appraisal system and subsequently select aspects for conscious awareness and further action. Hence, the feedback processes affect the very appraisals that helped initiate the neurophysiological, and other reactions, in the first place. The subjective feeling component has a special status in this emotion process as it monitors and regulates the component processes, taking into account all information about the continuous patterns of changes in the different components as well as their coherence. An individual's integrative, conscious, gestalt feeling-experience of an emotion, such as anxiety, is consequently the culmination of the integrated processing of multiple component systems.

Mutual Regulation of Component Systems

The exact nature of the integrated processing of component systems that characterizes an emotion is further clarified by the second principle underlying this approach, i.e., that all the components mutually regulate each other over time and within a particular context. The insertion of the time dimension fully recognizes that an emotion, as a process, takes place during a specific episode. Within this episode, the different systems regulate each other through a variety of feedback loops starting from initial appraisal processes and resulting in an emotional experience.

According to Lewis' conceptualization, emotional processes begin with subconscious "coarse processing" when attention shifts (see Lewis, 2000, p. 43). For example, an individual may take in a global perception of an external stimulus and provide a global cognitive–affective interpretation that it contains important information ("Is the teacher handing back our test grades?"). During global processing, cognitive perceptions, interpretations, and appraisals, along with the integration of physiological components, result in a holistic "gist" of the situation and its potential for personal impact. Once the subconscious gist is in progress, recursive feedback processes among the subsystems influence refined evaluative processes (micro-cycles) that culminate in the emergence of coordinated cognitive awareness, cognitive–affective appraisals, physiological responses, and behavioral action tendencies. For example, early subconscious appraisals may highlight an exam score as potential information about expectations and reaffirming goals. This gist of information could ignite physiological processes that are experienced as a rush of arousal. These initial processes instigate further coordinative processing, resulting in an emergent appraisal-emotion amalgamation, or "*emotional interpretation*" (p. 43, Lewis, 2000) that is experienced as excitement ("I didn't fail! I got 95% correct!"), along with a rush of invigorated confidence and motivation ("I can do this! OK, what's next?"). The spontaneously coordinated emergence of thoughts and physiological sensations eliminates the question of which process, or element, occurs first (cognition or emotion?). From a DST point of view, all systems are simultaneously and iteratively involved. As explained by Lewis (2000, p. 43), "appraisal processes can be reconceptualized as emergent order in the cognitive system corresponding to, but not preceding, emotion".

An important addendum to this description is that an emotional experience will shape the person's further behavior and/or set the stage for new appraisal processes that again modulate

changes in component systems. Hence, the on-going mutual feedback processes, result in subsequent, new emotion(s). The feedback loops that characterize the mutual regulation between the various component systems not only clarify the process of a specific emotional experience, it also allows for a better understanding of the dynamics underlying the succession of several emotions over a short period of time, caused by rapid changes in events and/or evaluations (e.g., Scherer & Tannenbaum, 1986). As an example, imagine a student who sees his teacher entering the class with an unusual look on her face. The student feels an uneasiness, an undefined restlessness that becomes stronger the moment he notices that the teacher does not take her textbook out of her bag, but instead, removes a stack of papers. The student's uneasiness turns into fear (he did not study his lesson last night) the moment the teacher starts distributing the papers to the students, asking for silence. Receiving his sheet of paper, he discovers that it contains information about the arrangements for the next school play and becomes relieved (it is not a test) and excited (he wants to be in the school play).

This succession of experienced arousals and emotions might have taken place within a time episode of just one minute. The interactions between initial appraisal processes and the other relevant component systems explain the appearance of the first emotional reaction (i.e., fear), but the principle of mutual regulation among the systems also clarifies why a change in interpretation and appraisal of the event (it is not a test, simply information) can rapidly cause changes in other systems resulting in a new emotional reaction (i.e., relief), evolving quickly into another emotional experience (i.e., excitement).

Data from our own studies point to the succession of several emotions as typically characteristic of students' mathematical problem solving (see Op 't Eynde & Hannula in press; Op 't Eynde, De Corte, & Verschaffel, in press a, b). We carried out a multiple case study in the second year of junior high school with sixteen target students (age 14) of four classes in four different schools. In four successive lessons, all students of the four participating classes were asked to solve four (one for each lesson) rather complex realistic mathematical problems, each consisting of several subtasks and taking students about 25 minutes to complete. The sixteen target students' problem-solving behaviors were investigated more closely, using a combination of (on-line) questionnaires, thinking aloud, and video-stimulated recall interviews to determine students' beliefs and perceptions related to their motivational, emotional, and cognitive processes. A triangulation of data enabled us to reconstruct the different processes involved in students' solving of these mathematics tasks in the classroom. Figure 1 is a graphical representation of the succession of emotions that Belinda experienced when trying to solve one of the problems consisting of four subtasks.

When confronted with the problem, Belinda stated that "she did not really feel up to it". She felt sad because of something that happened at home right before she came to school. Nevertheless she wanted to "go for it" and tried to solve the task. She first attempted to tackle subtask 1, which was hard for her. She gradually became annoyed when she discovered that she did not find the solution. She then decided to leave subtask 1 and jumped to subtask 3, which looked like a task she might be able to solve. Indeed, she managed to solve that task giving her a feeling of confidence and new energy to tackle the next subtask. However, in doing so, she rapidly encountered difficulties that, at first, annoyed her. Gradually, her annoyance evolved into frustration, and finally developed into anger toward herself for not being able to find the solution. She persisted in searching for the answer (in a not very effective way, however) and finally, the signal indicating the end of class, brought relief.

When analyzing all sixteen students' problem-solving behaviors from a multidimensional perspective—addressing emotional, cognitive, and conative processes—we found that, in general, there was an individually changing flow of emotional experiences derived

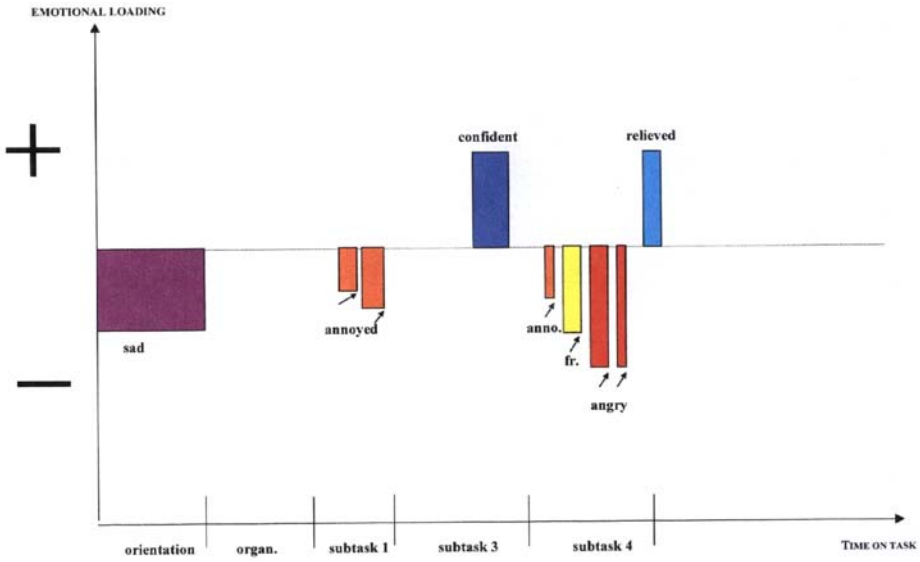

Fig. 1 A graphical representation of the emotions Belinda experienced solving a mathematical problem.

from students' interpretations and appraisals in the on-going series of events that occurred during their mathematical problem solving in class (see, Op 't Eynde *et al.,* in press a, b). The principle of mutual regulation between the different component systems enabled us to understand the emotional dynamics underlying this phenomenon. At the same time, however, these examples illustrate how emotional reactions are fundamentally determined by inputs from the (perceived) context in several ways. This is an important distinction of dynamical systems theories and an important focus of our research projects (e.g., Op 't Eynde, & Hannula, in press; Op 't Eynde, *et al.,* 2001; Turner & Waugh, 2003; Turner & Waugh, in press).

Context Sensitivity of Component Systems

The third element in Mascolo *et al.*'s (2000) component system framework is that "component systems not only adjust themselves to each other but also to continuous changes in the environment, or social context" (p. 127). Students' appraisal processes that are concomitant with initial emotional processes are grounded in a specific context. Not just because the different components of the immediate context (e.g., the teacher's presence, how she looks, what she says, the characteristics of the specific subtask, etc.) are the objects of appraisal processes, but more importantly, because the meanings attached to the situation are based on the knowledge and beliefs one has connected to the situation. In line with socio-constructivist views on learning, knowledge and beliefs are social in nature and embedded in the specific, and more broad, socio-historical context(s) (e.g., Cobb & Bowers, 1999; Greeno *et al.,* 1996; Volet, 2001).

For example, the different categories of students' beliefs related to mathematical learning and problem solving are not only determined by the immediate class context, but also by former mathematics classrooms and activities in which they participated, their home

cultures, the beliefs about mathematics held by parents, and the ideas about mathematics and mathematics learning held in the broader socio-cultural society (McLeod, 1992; Op 't Eynde, De Corte, & Verschaffel, 2002). Notwithstanding this, the immediate classroom context has a strong influence on students' knowledge and beliefs. After all, what counts as mathematical knowledge, what is correct or wrong, what is accepted as a good problem-solving strategy in a specific mathematics classroom resides in the interactions among the teacher, the pupils, and the books that are used—interactions that are directed by the "taken as shared" classroom norms, rules, and practices that regulate classroom life (Yackel & Cobb, 1996). Students' knowledge and beliefs reflect, at the individual level, these "shared" norms and practices related to mathematics learning.

In summary, the situatedness of students' meanings and emotional experiences in the classroom are fundamentally constructed in a twofold way. First, students' meanings and emotional experiences are socially constructed through students' intrinsic relationship to the different elements in the specific situation. After all, emotions are always about something (Solomon, 1976). Second, students' meanings and emotional experiences are socially situated because of the social nature of each individual's knowledge and beliefs. In line with Paris and Turner's (1994) characterization of situated motivation, one can claim that every emotion is situated in its instructional context by virtue of four characteristics. First, emotions are based on students' cognitive interpretations and appraisals of specific situations. Second, students construct interpretations and appraisals based on the knowledge they have and the beliefs they hold, and thus, individuals' interpretations are influenced and vary by factors such as age, personal history, and home culture. Third, emotions are contextualized because individuals create unique appraisals of events within situations. And finally, emotions are unstable because situations, and also the person-in-the-situation, continuously develop.

Self-Organization of Component Systems

The fourth element in Mascolo *et al.*'s (2000) component system framework is that "emotional experiences self-organize into a series of more or less stable patterns or attractors that yield a large number of minor variations" (p. 127). Indeed, a component systems approach supports the view that an emotional experience is constituted by different component systems that mutually regulate each other within a specific socio-historical context. Grounded in an individual's salient goals and concerns, and determined by his knowledge and beliefs, these processes modulate the organization of any given emotional experience in a specific context. This implies that, although an infinite number of interactions are possible, emotional processes have a tendency to *self-organize* into a finite number of stable patterns or *attractors*, based on the relative stability of certain kinds of knowledge, beliefs, goals, and concerns within and between individuals in a specific socio-historical context.

Attractors bring stability and predictability in two ways. First, when component systems configure in specific ways, identifiable patterns may be labeled. As pointed out by Mascolo *et al.* (2000), such patterns can account for the existence of emotional-states of basic emotions (e.g., anger, fear, love). These states have common, identifiable patterns across individuals. For example, the emotion of shame occurs when an individual perceives that he or she has failed to achieve in an area of personal importance (Turner & Schallert, 2001). The perceived failure (e.g., answering 88% of items correctly on an exam) may not be an

objective failure (e.g., answering 50% of items correctly on an exam). Perceived failure, especially when one expected a different outcome, along with attributions to the self for the failure, are consistent cognitive patterns of shame reactions. These cognitive patterns are also associated with physiological patterns of high arousal along with feeling hot and flushed. Motivationally, a student feeling shame also has "action tendencies" such as wanting to be alone. These patterns of component systems for the emotion of shame are consistent across students (for more details on dynamical properties of shame, see Turner & Waugh, in press).

Another way in which attractors bring about stability is through individually-repeated patterns. Although an individual may have the potential to manifest an infinite number of component systems patterns, an individual will have a fairly-consistent tendency to self-organize into a smaller number of stable patterns. Over time, an individual develops his or her individual patterns because of a tendency toward specific attractors (e.g., personal values, appraisals, etc.). Individual stability emerges because of an individual's relatively-stable knowledge, beliefs, goals, concerns, etc. Similar to the idea of a "habit", attractors become subconscious, somewhat stable, tendencies. In terms of "attractors", one theory that has provided an important framework for our research is Pekrun's (2000) social cognitive control-value theory of academic emotions and motivation (see also Pekrun, Goetz, Titz, & Perry, 2002).

Building upon existing expectancy-value theories of academic motivation (e.g., Eccles, 1983; Pekrun, 1993, 2000; Pintrich, 1988, 1989; Wigfield & Eccles, 2000), Pekrun's (2000) theory particularly illustrates how relationships of students' motivations, cognitions, emotions, and learning can be influenced by initial control-related and value-related beliefs students bring to the learning situation. Shaped by characteristics of their classrooms and social environments (contextual sensitivity), these beliefs influence students' appraisals of academic tasks (cognitive component) such as the extent to which they perceive that they can or cannot control the outcome and the extent to which they place a high or low value on the "successful" completion of their academic tasks. Students' personal appraisals of control and value simultaneously influence the manifestation of other component system processes. Students may experience enjoyment in participating in an interesting activity or anxiety in participating in an unknown and frightening activity, depending on different sets of control and value appraisals (appraisal-driven mutual-regulation of component systems).

Notwithstanding the existence of intra- or interindividually recurrent general emotional patterns (attractors) based on the self-organizational force of control-related and value-related beliefs, numerous minor variations remain possible in the produced-pattern of component systems. As such, small differences in an individual's knowledge and beliefs, as well as in the specific characteristics of the local social context, determine the initial appraisal processes and can result in significantly different emotional experiences of, for example, anger or fear with possibly different behavioral consequences. In dynamical systems theory, this phenomenon is referred to as the '*sensitive dependence on initial conditions*' implying that "even small differences in conditions under which different emotional experiences arise can lead to increasingly large differences in their organization" (Mascolo *et al.,* 2000, p. 134). This dynamical aspect implies that, not only, the sadness people feel in one social context (e.g., the mathematics class) can be of a totally different kind than the sadness they feel in another context (e.g., the English class), but the sadness that student X experiences as a consequence of what just happened in class might be different from the sadness that student Y experiences in the same situation. Students' differing experiences are a consequence of their possessing different knowledge, holding

different beliefs, making different appraisals, etc. Still one step further, even a student's experience of sadness in today's class caused by getting a 'bad' grade might be different from the sadness he experienced a week ago upon receiving the same grade in the same class; the class situation, as well as his beliefs and goals might have changed.

This may appear to be a silly word game but therein lies part of the problem. We must label emotional experiences to talk about them and to conduct research about them. Often, the same label is used to refer to emotional experiences that, although they seem to share some basic structure, the pattern of component systems might be slightly different and, as such, the experienced emotion may be different as well. We could simply disregard this complexity because we lack the tools and words to fully question the relevance of these subtle differences or to capture their distinctions. However, fully acknowledging the complexity of emotions and their processes, and looking for ways to properly study them, may be just what is needed to push our research on academic emotions further (see also Scherer, 2000).

Investigating the Roles of Emotions in Classroom Learning: Methodological Issues

The perspectives from which we conduct research on the role(s) of emotions within classroom learning, focuses on an integration of a socio-constructivist account of learning and a component systems approach of emotions. This necessarily implies: (1) holding a conception of learning as a situated process constituted by the interactions among cognitive, emotional, motivational, and volitional processes, and (2) holding a conception of emotions as consisting of multiple component systems that mutually regulate each other in a specific context, i.e., the academic classroom. In our opinion, the integration of both perspectives provides a comprehensive and promising theoretical framework for the study of the role(s) of *emotions* within classroom *learning*, involving a clear shift in the research methodologies and instruments used to investigate these phenomena. Figure 2 represents a situated, multidimensional model of learning within the classroom that can serve as a framework for research on the integrated relationships of cognitions, emotions, and motivations within classroom learning (and has served as the framework for our research) provided that the following principles, described in the next section, are taken into account.

Studying the Student-in-the-Classroom

The situatedness of emotions or emotional experiences, and of classroom learning in general, forces research from this perspective to take place within the classroom. A study of the integration of students' cognitions, emotions, and motivations within classroom learning must document how students engage and reorganize their classroom perceptions and participation as well as clarify the role(s) of emotions in these processes. This approach integrates intentionality and emotionality with intellectuality, and uses meaningful activity, from the learner's perspective, as its basic currency. In this sense, emotions are not treated as objects that can be studied as independent and detachable from the individual's processes and context (Cobb, Yackel, & Wood, 1989). To study, for example, a student's enjoyment, implies an analysis of joyful interpretation and acts as they occur within contexts and activities—in our case, in the context of classroom learning. Therefore, most of our studies are located in the classroom and they analyze students' learning behaviors in their natural setting (see e.g., Op 't Eynde *et al.,* in press a, b; Turner, Husman, & Schallert, 2002).

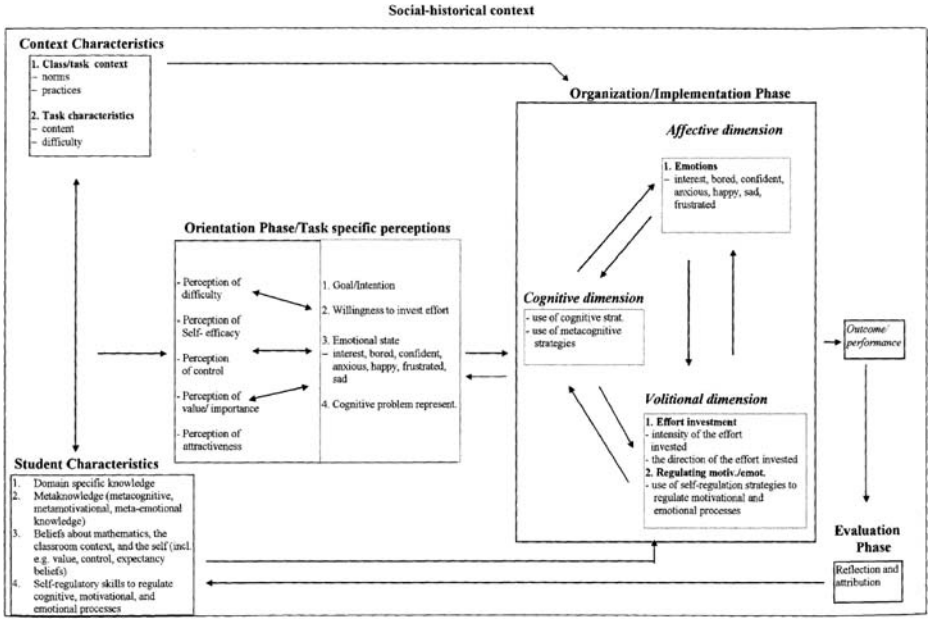

Fig. 2 A multidimensional model of classroom learning.

Taking an Actor's Perspective

The focus on the meaning of emotional activities, and of learning activities in general, implies a shift of research-focus from an observer's perspective to an actor's perspective (Cobb & Bowers, 1999). What matters is not so much students' activities and the classroom environment and practices as observed by the researcher, but the appraisals, interpretations, and meanings students give to the classroom and its practices, and upon the meanings for which they act. Through their interpretations and actions, students continuously create new, initial conditions to which they interact in different ways. Students' emotional experiences, as determined by students' interpretation and appraisal processes, are partly grounded in these continuously changing meaning structures. To grasp the dynamical interplay between the student and the class context, a variety of research methods are required. Interviews, observations, and discourse analysis seem to be more appropriate methods for revealing the meanings that students give to situations and how emotions are constituted through class interactions, than, for example, using only questionnaires (Cobb *et al.,* 1989; Turner & Meyer, 1999). However, to really grasp the dynamics of the interplay between student and context, to really grasp the dynamical nature of emotional experiences within the classroom, methods must be developed and applied that allow the on-line tracking of the various component processes that are engaged.

Measuring the Different Component Systems

On-line questionnaires, experience sampling methods, and video-based stimulated recall interviews, are examples of appropriate techniques that may be used to assess the

continuous flow of interpretation and appraisal processes involved (see e.g., Boekaerts, 2002; Leder, 1999; Op 't Eynde & Hannula, in press; Op 't Eynde *et al.,* in press a, b; Prawatt & Anderson, 1994). However, an emotional experience is constituted by the mutual interactions among different component systems of which the appraisal system is but one. The use of facial coding systems and registration systems of physiological parameters (see e.g., DeBellis, 1996; Isoda & Nakagoshi, 2000) that capture the changes in the motor expression component and the neurophysiological component should complement information about students' appraisal process to obtain a more comprehensive picture of on-going emotional experiences. However, currently, few instruments are available to measure the various components with reliable means within classroom situations (e.g., compared to laboratory contexts that provide more means to reliably assess the neurophysiological component).

From an Isolated to a Multidimensional Approach

Analyzing the emotional dimensions of students' activities in the classroom cannot take place in isolation from the study of cognitive and motivational processes. Although different in nature, we have described the complex and close interactions among these processes. On one hand, the emotional experience itself consists of multiple interactions among different component systems. On the other hand, within learning activities, students' emotional experiences are intricately linked to the learning goals for which students' strive and the cognitive and metacognitive strategies they use to obtain their goals. Studying the emotional dimension of learning, separated from the (meta)cognitive and motivational dimensions, one could never fully grasp the complexity of students' learning activities within the classroom. A student is not only driven by his or her immediate emotions, but also by his/her thinking and wanting along more abstract levels. A unidimensional analysis of a learning activity neglects the complexity involved with student's multiple goals, aptitudes, and personality characteristics. It is only when a multidimensional approach is taken that the study of emotional experiences can provide us with valuable insights into students' learning within the classroom (see Fig. 2).

A Multilevel Approach for a Deeper Understanding

Focusing analysis on an individual student's emotional experiences within a classroom, one can reveal how the student continuously interprets and appraises the learning situation and acts accordingly. A meta-level analysis of the appraisal processes throughout learning activities can disclose students' beliefs and knowledge structures underlying their emotions and subsequent actions, leading to a deeper understanding of students' learning processes. However, to fully understand the nature of students' beliefs and the consequences of their actions, an analysis of the norms and practices that characterize students' classrooms, is also necessary. One might even take the analysis one step further, incorporating a study of the rules and values that are dominant in the school community and the local community as well. A "multilevel" approach that incorporates several planes of analysis, corresponding to personal, interpersonal, and community values, appraisal processes, etc., will probably result in the most complete understanding of students' emotional experiences and learning activities (see Op 't Eynde *et al.,* 2001; Rogoff, 1995).

Summary and Discussion

We believe that dynamical, component systems approaches present a promising and integrative conceptualization of students' emotions within school learning. Three main principles provide the basis of this new approach. Firstly, this approach emphasizes emotion-related *processes* that characterize emotions as an emotional episode within which different component systems co-regulate and co-act. The mutual feedback processes among these systems, within a specific context, constitute emotional experiences and explain their dynamical nature. Thus, emotional experiences emerge on-line within a specific context through the interactions among a cognitive component (appraisal), a neurophysiological component, a motor-expression and motivational component, and last but not least, an integrated, gestalt feeling component.

Secondly, dynamical component systems approaches point to the social nature of emotions. Emotional experiences are always situated in the immediate and broader social–historical context. This does not imply, however, a denial of the relevant biogenetic and organismic processes. On the contrary, socio-cultural systems co-act with biogenetic and organismic systems in every emotional experience and together they influence an individual's emotional development. For example, as the brain grows, individuals are able to obtain a more detailed understanding of cultural meanings resulting in the capacity to construct higher-order event-appraisals that lead to emotional development. Cultural systems work together with an individual's biological systems to construct emotional interpretations, understandings, and changes (Mascolo *et al.,* 2000).

Finally, dynamical component systems approaches to the study of academic emotions point to the non-chaotic nature of inherent interactive feedback processes, clarifying that emotions self-organize in real time as well as within specific contexts. Framed by the specific socio-historical context, emotional experiences tend to self-organize into a finite number of stable patterns, i.e., basic emotions. However, due to the fact that, in real time, emotional experiences evolve from different starting points related to individual differences and/or differences in appraisals/interpretations of the specific context, different patterns of component systems interactions will be produced—even within each 'basic' emotional category. The sensitive dependence of emotional experiences on initial conditions account for numerous variations found within each basic emotion category. These variations are not trivial and, although many times labeled with the same emotional term, can refer to large differences in the organization of component systems and thus in the experience of the emotion.

The research approaches and methodologies outlined throughout this paper provide some idea of what it means to address emotions in their full complexity when studying the roles that emotions play within classroom learning. You may consider the different characteristics discussed in this paper as potential criteria for sound study, but from another perspective, these characteristics contain the elements of an entire research program. In any case, they represent a real challenge to research the complex roles of emotions within the classroom.

Additionally, we believe in the importance of further investigating the complex ways in which emotional processes interact with conative and cognitive processes to determine classroom learning. Still far too often, the head (cognitions) and the heart (emotions) are perceived as two distinct entities when learning is concerned. Interestingly, teachers and parents are sensitive to children's feelings at and about school and learning. They believe an important goal of education is that students *enjoy* learning and feel *positive* (and safe) at school. In most cases, these affective aptitudes are perceived as educational goals on their

own, next to the cognitive "standards" that must be attained. The affective (heart) and the cognitive (head) dimensions of learning and instruction have become accepted as, "in principle", equally important but separate. Consequently, teachers find themselves regularly confronted with the question of which one of these dimensions deserves priority in a specific situation or, more abstractly, within the curriculum. Not surprisingly, because schools are primarily institutions that are entrusted to provide students with (basic) knowledge and skills, teachers, parents, and society place importance on students' cognitive acquisitions over students' emotional feelings about the learning processes. By further developing a researched understanding of the various interrelated and integrated ways in which cognitive-emotion-conative processes function within academic learning, will we be able to remove the perceived wall that superficially exists between the head (cognitions) and the heart (emotions). Only then will we clearly be able to demonstrate to teachers and parents that the emotions students experience during academic lessons, students' motivational energy for engaging in the learning process(es), and students' acquisition and use of academic knowledge and skills are undeniably, inextricably linked. We think that using a dynamical component systems perspective for studying emotions within academic settings provides a powerful empirical framework for stimulating research towards that level of understanding.

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