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AFFECT AND SELF-REGULATION

ABSTRACT. This paper presents affect as an essential aspect of students' self-reflection and self-regulation. The introduced concepts of self-system and self-system process stress the importance of self-appraisals of personal competence and agency in affective responses and self-regulation in problem solving. Students are viewed as agents who constantly interpret and evaluate their experiences and regulate their behaviour, in interaction with their mathematics learning environment. This perspective is used to interpret two data sets: Finnish secondary school students' questionnaire responses and their mathematics achievement, and Frank's problem solving episode. The former study examines statistical relations between self-confidence, positive and negative affective responses, self-regulatory patterns, and math performance. The latter focuses on Frank's appraisals and self-regulatory processes with his affective responses while problem solving. Finally, I consider the perspective's usefulness and compare it to others in this Special Issue.

KEY WORDS: affective responses, self-appraisals, self-system processes, self-regulation

1. Introduction

Previous mathematics education research on affect has discussed constructs like self-concept, self-esteem or self-confidence and their connections with mathematics performance (Seegers and Boekaerts, 1996). Such studies have also analysed powerful negative affective responses like mathematics anxiety (Hembree, 1990). The negative relations between self-concept measures and math anxiety, as well as their connections with variation in mathematics achievement, problem solving or learning behaviours like persistence (Malmivuori, 2001; McLeod, 1992) emphasise the strong interconnections of mathematics thinking and students' self-perceptions. Here I emphasise the role of self-perceptions in affective responses, as well as in mathematics learning. The key concepts of self-system and self-system process can explain important research results on affect in social learning environments, drawing on socio-cognitive and constructivist perspectives on affect and self-regulation (Bandura, 1993; Mandler, 1989). Accordingly, learning, affective responses and activity are powerfully engaged in students' personal and unique situational constructions, experiences and regulation of actions. Thus, consistent with 'humanistic' approaches to learning and self-regulation (Deci and Ryan, 1991; Polkinghorne, 2001),

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we locate explicitly the self and (personal) agency at the centre of students' personal mathematics learning and problem solving.

Here I focus on relations between students' self-appraisals, affective responses and self-regulation. I connect the self to constructs like self-confidence, self-esteem, self-efficacy and self-awareness in mathematics learning processes. By notions of personal agency and self-system process I stress not only a student's self-reflection and self-regulation of behaviours and affective responses in mathematics learning but also the dynamic and creative aspects of learning and affective experience. All these terms signify features and processes referred to as metacognition, self-regulated learning and also motivation. I connect these to the functioning of students' self-system processes, but do not specify here the energizing or volitional aspects (such as intentions, goals, self-motivation) behind students' actions (Malmivuori, 2001). Section 2 presents the theoretical background for our perspective on affect. Section 3 considers a quantitative study of Finnish secondary students' math self-system structures and affect. In turn, Frank's case allows connection of self-system processes to qualitative data obtained in the studies of Belgian high school students (Op't Eynde et al., this issue). Finally, I discuss the relevance and connections of my perspective in Section 4.

2. Theoretical viewpoints

2.1. *Affect and the self*

The tendency of educational research to treat affect as a personality domain, separate from the cognitive and to produce many different conceptualizations has caused difficulties in understanding the area (Malmivuori, 2001). Yet, mathematics learning and problem solving have provided fruitful contexts for study. Affective factors, especially attitudes towards mathematics, have been studied in mathematics education since the 1970s, but only recently has sufficient attention been paid to theorisation of affective factors. Various developments in recent general educational, psychological and social psychological research have helped to interpret the role of affect also in mathematics learning. Like other researchers in this area, I use these perspectives to study affect and self-regulation.

Firstly, this literature exhibits fairly consistent agreement on the involvement of physiological and/or psychological *arousal* in affective responses, especially in unexpected or rapidly changing situations (Mandler, 1989). Moreover, recent cognitive theories of emotion view unconscious or preconscious *appraisals* as antecedents of arousal (Lazarus, 1991; Ellsworth and Scherer, 2003). I argue further that at least more complex emotions are aroused by individual, situational appraisals of events as relevant to important goals or concerns (Schutz and DeGuir, 2002). Further, powerful emotions are linked to students' personal and situation-specific *appraisals of the self* with respect to their goals and effort in math classroom interactions (cf., Boekaerts, 1995; Turner et al., 2002). Consistent with 'self-concept theories' of learning and motivation (e.g., Covington and Roberts, 1994), we consider students' behavior and learning outcomes as the consequences of their perceptions, appraisals and experiences of self. The term *self-emotion* (Blasi, 2004; or self-affect, Harter, 1985) is used here for powerful emotions like shame, guilt, anxiety or enjoyment involved in students' experiences of self-esteem, efficacy and control. These responses relate especially to their beliefs and perceptions of personal capability and agency in mathematical situations.

2.2. *Self-system and self-system processes*

Self-system and self-system processes have been, for me, the basic concepts for portraying the functioning of affective responses in mathematics learning (Malmivuori, 2001, 2004). With these terms (cf., Borkowski et al., 1990; Connell, 1990) we aim to create links among affective, cognitive and behavioural personality domains, and to stress personally significant mathematics learning processes. By *self-system* we mean stable internal structures including:

- content-based mathematical knowledge, but also
- learned socio-cultural beliefs about mathematics, its learning and problem solving
- beliefs about the self in mathematics
- affective schemata
- habitual behavioural patterns in mathematical situations.

All these structures derive from students' past history with mathematics in social environments. School mathematics learning and wider aspects of culture (e.g., beliefs about the usefulness of mathematics or about the nature of math abilities) linked to it provide contexts for the development of mathematical self-systems. Once activated, these self-systems are the basis for the functioning of students' self-system processes in mathematical situations, that is metacognitive, cognitive and affective capacity used in mathematical thinking. Ultimately, situation-specific factors condition the functioning of students' self-system processes and, hence, the quality of their mathematics learning experiences.

Consideration of features such as challenges to personal capability and management of effort expenditure in achievement context, underlines the importance of self-appraisals, together with accompanying powerful emotions and possible difficulties in the orientation and control of affective responses. The notion of *the self* and *self-system processes* organizes these mental processes, affective responses, behaviours and their regulation. Whilst treating the cognitive self (e.g., the mathematics self-concept) as central in stable self-systems, I present the experiential self as even more important in personal learning experiences. The latter – nonrepresentational (Blasi, 2004) – aspect is stressed in recent phenomenological/humanistic theories of learning and self-regulation (e.g., McCombs, 2001). I connect these *dynamic features of the self* to personal agency and the functioning of self-system processes related to mathematics (Malmivuori, 2001; 2004). The qualities of both self-systems and self-system processes determine also the power and role of affect in mathematics learning.

2.3. *Affect and self-regulation*

Metacognition is central to affective issues in mathematics learning and problem solving (Schoenfeld, 1983; McLeod, 1992). The idea arose from information-processing theories of knowledge and has been used to explain differences in students' cognitive performances. Social learning theories of self-regulated learning (Zimmerman and Schunk, 2001) and control-process views of behaviour (Carver and Scheier, 1990) deal with related issues. Here, I focus on these *metalevel* (i.e., self-reflective and self-regulatory) aspects of students' affective experiences as the primary level of self-system processes in mathematics learning and use. Metalevel constructions and processes constitute the basis for the individual and situation-specific variation and development of students' mathematical knowledge and skills, affective responses, and use of personal resources in mathematics learning (Malmivuori, 2001). I concentrate on the connections among students' powerful affective responses, self-appraisals and self-regulation in mathematics learning and problem solving.

Generally, emotions are viewed as fulfilling important organizing, motivating and regulating functions, e.g. of other affective responses, as when interest attenuates fear (Goldin, 2000). They establish additional goals related (or not) to learning intentions and possibly cause conflicting action tendencies (Kuhl and Kraska, 1994; Lazarus, 1991). Within self-system processes, affective responses direct or disturb students' thinking, but also provide information about e.g. mental activities in mathematical situations. This information activates various self-regulatory processes at different levels of self-awareness (Taylor et al., 1997), including self-reflection, self-appraisals and *self-directive* or *self-control actions* accompanied by and/or directed towards affective arousals. In describing the (promotive) role of emotions in self-regulatory processes we point to Hatfield (1991) who connects high quality mathematical experiences to emotional states (feeling) and inquiry states (thinking) in which the emotional elements involve a sense of purpose, self-perception of potential for success, and willingness and capacity to monitor and control the effects of one's feelings.

In illustrating important features of affect in self-regulation processes we contrast active regulation of affective responses with automatic affective regulation (Malmivuori, 2004). *Automatic affective regulation* refers to an affective feedback system dominating the evaluation system and behaviour at a relatively low level of control. This self-regulatory activity acts at unconscious or preconscious levels (Taylor et al., 1997). Mental blockages, simplifications and hindering of higher order mental processes due to strong negative affective responses are examples, whereas intensification of performance processes and change of thought contents provide positive examples of automatic affective regulation. Integration of such dynamics has a major influence on personality organization and individual differences in affective development. Based on this integration I point to students' conscious monitoring of their own affective responses and their conscious decisions related to the effects of these on their mathematical thinking and learning. Affective responses and the states of the self then become objects of evaluation and regulation. We refer to these self-system processes as *active regulation of affective responses*.

The essential difference between automatic affective regulation and active regulation of affective responses is connected to the level of *self-awareness* and *reflectively directed activity* within students' self-system processes. Affective regulation represents automatic or habitual self-regulation with weak self-reflection and personal agency, while active regulation of affective responses is involved in high agency, high self-awareness and efficient self-regulatory processes. The former activity relates to habitual structures in stable self-systems, characterized by arousal of similar, often interfering affective responses leading directly to habitual behaviours (e.g. particular defensive actions or intentions). Actions and affective responses in mathematical situations are then determined mainly by stable self-systems. In contrast, active regulation of affective responses is connected to students' high personal agency with effective and creative self-system processes. Here students' actions and affective experiences may be relatively independent of their stable self-systems as well as of the social features of the learning context. Overall, personal agency and self-awareness strongly influence the development of and variation in students' affective experiences, and the role of these in mathematical performance (Malmivuori, 2004).

3. Illustrations of the Perspective

3.1. *Quantitative study*

First, I will discuss the results of a quantitative study of Finnish seventh-grade students' mathematical beliefs, affective responses, self-regulatory patterns and mathematical performance. We use correlation analysis to illuminate significant structures of students' *stable mathematics self-systems*, and relationships between self-appraisals, affective responses, self-regulation and performance. Previous findings show close connections between self-perceptions, affect and performance in mathematics (e.g., Meece et al., 1990; Skaalvik, 1997). Studies of the relations between self-perceptions and self-regulation of learning have appeared in general education research (e.g., Borkowski et al., 1990; Garcia and Pintrich, 1994). Also, Pekrun et al. (2002), for example, considered emotions and the quality of self-regulation. We deal here with both of these issues in the context of mathematics learning and take into account the mediating role of students' powerful affective responses between their self-appraisal modes and their few important self-regulatory patterns in learning and doing mathematics and mathematics performance. The emphasis in the considerations is more on the relations between self-contructs, self-emotions and self-regulatory behavioural patterns than on the relations of these to achievement in mathematics.

3.1.1. *Data collection*

The quantitative data for the study were gathered from 346 female and 377 male seventh-grade students (age 13) in 17 different public lower secondary schools in a Finnish metropolitan area in the beginning of a school year. Students responded to two separate self-report questionnaires in which the statements measured students' beliefs about school mathematics, about themselves as mathematics learners, their affective responses towards mathematics and their behavioural patterns in math classes. The responses to the statements varied along with a continuous scale ranging between -5 (strongly disagree) and $+5$ (strongly agree). Students' performance was measured by a *mathematics test* with 26 problems about numbers and different calculations, various spatial and words problems, and examination of patterns (Malmivuori and Pehkonen, 1996). Separate exploratory factor analyses performed on responses to sets of statements in the questionnaires confirmed the 9 separate scales used in the analysis in this paper.

3.1.2. *Measurements*

The self-confidence scales of the study measured students' self-appraisals with respect to mathematics and mathematics problem solving. Most of the statements were derived from Fennema and Sherman's (1976) Confidence scale with the rest designed especially for the purposes of this study (Malmivuori, 1996). Two separate scales, *self-efficacy* and low self-esteem, were constructed using the factor analyses. The first construct reflected students' belief in their ability to study advanced mathematics and to succeed in mathematics. *Low self-esteem* measured students' tendency to doubt their math skills and performances with weak self-control reflections. Naturally the two constructs correlated negatively with each other ($r = -.45$), but both of these indicated single dimension of students' general math self-confidence (Malmivuori, 2001). Negative self-emotions were measured by two mathematics anxiety scales, based on items designed on the basis of theories and measures of general anxiety, math anxiety and test anxiety (Sarason, 1972; Wigfield and Meece, 1988). General *Fear of mathematics* indicated students' tendency towards fear and confusion in mathematical situations. Math *Test Anxiety* reflected students' worry and nervousness about math tests.

Also positive affective responses (self-emotions) were measured by two closely related scales: *Enjoyment* and *Liking* of mathematics ($r = .78$). The included scales for students' self-regulatory behavioural patterns consisted of *Persistence* in doing and learning mathematics, *Integration* (i.e., tendency to integrate new math knowledge with previous knowledge and experiences), and *Preference for challenge* (or risk-taking) in mathematics. The statements for self-regulation scales were adopted partly from the Motivated Strategies for Learning Questionnaire (MSLQ) scales by Pintrich and DeGroot (1990) and from the failure tolerance scales by (Clifford, 1988) and partly constructed for the study. The estimated Cronbach alphas scores for the self-confidence scales were .83 (self-efficacy) and .79 (low self-esteem). The alphas for affective response scales varied between .84 (liking mathematics) and .77 (fear of mathematics), and for the self-regulatory scales between .82 (prefence for challenge) and .70 (persistence). Sample items of the scales are presented in Table I.

3.1.3. *Results: Correlations*

Generally, analyses of all the constructed math belief scales in the questionnaires revealed that, again, students' math self-confidence was the most powerfully connected to their reported affective responses, self-regulatory

TABLE I
Scales and sample items of the study

Scale	No. items	Sample items
Self-efficacy	4	'I could surely come off more difficult maths.'
Low self-esteem	4	'I am not the type who succeeds in mathematics.'
Fear of mathematics	6	'I often feel relieved after math class.'
Test anxiety	6	'I am always worried about my success before math exams.'
Enjoyment of maths	3	'I find mathematics as enjoyable school subject.'
Liking of maths	4	'I like solving mathematic problems.'
Integration	5	'I try to connect new things with what I already know of mathematics.'
Persistence	6	'I complete solving math problems even though they appeared boring.'
Preference for challenge	5	'Challenging and hard problems are the best part of mathematics.'

TABLE II
Intercorrelations among self-system constructs and math performance.

	3	4	5	6	7	8	9	10
1. EFF	.41	.44	−.45	−.26	.16	.39	.45	.28
2. LEST	−.37	−.39	.57	.49	−.02	−.32	−.43	−.42
3. ENJ		.78	−.65	−.22	.25	.51	.61	.18
4. LIK			−.65	−.27	.23	.49	.71	.26
5. FEAR				.47	−.11	−.46	−.64	−.31
6. TANX					.15	−.08	−.31	−.27
7. INT						.51	.13	.01
8. PERS							.44	.20
9. CHALL								.30

EFF = self-efficacy; LEST = low self-esteem; ENJ = enjoyment; LIK = liking maths; FEAR = fear of mathematics; TANX = test anxiety; INT = integration; PERS = persistence; CHALL = preference for challenge; 10 = test scores. Correlations above .15 were statistically significant.

patterns, as well as their math performance as compared to their other perceptions and beliefs about mathematics (cf., Malmivuori and Pehkonen, 1996). As suggested above, self-confidence operated hence as solder of students' significant self-systems in mathematics. Table II displays the linear intercorrelations between the students' reported self-confidence, affective responses, self-regulatory patterns and math test scores.

Firstly, the correlations in Table II confirm the important connections between students' self-confidence and their powerful affective responses in mathematics. The two self-confidence scales were clearly related both to the reported positive and negative responses. The strongest correlations appeared between low self-esteem and the two math anxiety measures ($r = 0.57; r = 0.49$). But, self-efficacy had also rather strong relations to the positive self-emotions. The self-confidence scales had clear correlations also with students' motivational kind of self-regulatory patterns measured here as persistence and preference for challenge (or risk-taking) and, further, with math test scores. On the other hand, the positive self-emotions, as well as fear of mathematics, had stronger relations to students' self-regulatory patterns of persistence and preference for challenge than the self-confidence measures. A moderate link further appeared between integration and the positive responses of enjoyment and liking of mathematics. Test anxiety had a role different from the other affective scales. It related clearly (negatively) only to risk-taking and test scores. The highest correlations between the self-regulatory patterns and self-confidence or the measures appeared for students' preference for challenge (risk-taking) in mathematics. Persistence was also clearly linked to these measures (not to test anxiety), but integration had only milder relations to these scales. In turn, both the affective scales and the self-regulatory patterns of persistence and preference for challenge had slight relations to math performance.

In order to examine closer the relations between powerful affect (self-emotions) and self-regulatory patterns in students' stable math self-systems, partial correlations were taken after controlling for the two self-confidence scales (self-efficacy, low self-esteem). Partial correlations for the self-regulatory patterns and math test scores are presented in Table III. Comparing these partials with the correlations in Table II reveals that all the affective responses mediate the effects of self-confidence on the

TABLE III
Partial correlations of the affective responses with self-regulatory patterns and performance after controlling for the two self-confidence scales

	Integration	Persistence	Challenge	Score
3. ENJ	.23	.41	.50	−.001
4. LIK	.21	.37	.61	.10
5. FEAR	−.09	−.30	−.50	−.07
6. TANX	.20	.11	−.12	−.08

ENJ = enjoyment; LIK = liking maths; FEAR = fear of math; TANX = test anxiety.

self-regulatory patterns as well as on test scores, at least to some extent. But, rather strong partials still appear between the self-regulatory patterns and students' positive responses of enjoyment and liking of mathematics and their fear of mathematics after controlling for self-confidence. This applies especially to students' preference for challenge. Accordingly, this positive self-regulatory pattern had clear connections to both powerful positive and negative affective responses that are further rather independent of students' self-confidence. The positive responses (self-emotions) have clear connections to increase in risk-taking and also to a bit slighter increase in persistence pattern, whereas general fear of mathematics seems to weaken these patterns. Instead, test anxiety had again a role different from the other measured affective responses. Its positive relation to integration and persistence slightly increased after controlling for self-confidence. This reflects the possible positive effect of test anxiety on behavioural patterns. On the other hand, most of the slight relations between the affective responses and math performance vanished after controlling for self-confidence, indicating again self-confidence's significant role in math performance.

The above quantitative results of Finnish secondary schools students' perceptions, responses, patterns and performance show close connections between self-confidence and powerful positive and negative affective responses (i.e., self-emotions) in mathematics. They also indicate important relations between students' self-confidence and their self-regulatory behavioural patterns in math learning or problem solving and their actual math performance. In all, self-confidence in mathematics plays a significant role in students' math self-system structures, including their powerful self-emotions as well as their important self-regulatory behavioural patterns and math performance (cf., Malmivuori, 2001). Moreover, powerful emotions (affective schemata) mediate the effects of students' confidence appraisal patterns on their self-regulatory patterns with mathematics. On the other hand, self-emotions seem to have significant connections to students' important self-regulatory patterns in learning and doing mathematics that are independent of students' math self-confidence levels. The above correlational analyses thence support the idea of the close relations between self-confidence and self-emotions, but also of the significant linkages between these and the quality of students' habitual self-regulatory behavioural patterns and performance in learning mathematics.

3.2. *Qualitative interpretations: The case of Frank*

Here I will illustrate the notion of students' ongoing *self-system processes* in mathematics. The core dynamics of affect in these processes was above connected to students' self-appraisals and self-regulatory processes at different levels of their self-awareness. The case of Frank will now be considered by using the descriptions and measurement of responses offered by Op't Eynde and his colleagues of Frank's problem solving episode and his interview while watching the video tape of the episode (Op't Eynde and Hannula, this issue). The focus is on Frank's self-appraisals and self-regulatory processes with his affective responses while working on subtask 2 of a math problem, not his favourite type of a problem.

The varying role of affective responses in self-regulatory processes was above discerned by two qualitatively different kinds of self-regulatory actions. Firstly, I perceive *automatic affective regulation* in Frank's immediate intention to go to his calculator after assessing that he had forgotten how to solve the given problem (Op't Eynde and Hannula, this issue). The behavioural reaction (i.e., intention) is automatic and he cannot control that intention very easily while feeling confusion and even panic. As Frank usually tries to avoid using calculator, this behavioural pattern and belief behind result in negative self-appraisal with powerful self-emotion (panic) that together give rise to this automatic (i.e., instant) self-regulatory intention (decision) without conscious self-control activity. However, Frank manages to avoid using his calculator after all. This means that he was able to finally *take control over* his panic reaction and, further, to *redirect his attention* towards the problem statements. He tells how he "stops and thinks for a moment", "this is not possible". Then he starts to think again and then he manages. This focused moment and Frank's *conscious decision* to start to think again produce him an idea what is needed for solving the problem. More efficient concentration on reading the problem statements with self-controlled panic promotes the activation of his adequate math knowledge and skills needed for solving the problem. Consequently, his more *positive self-appraisal* and feeling of having control again (self-confidence) are activated and panic reaction is clearly reduced or overcome, resulting in more efficient utilization of personal math knowledge in solving the problem.

Even more detailed intepretations can be drawn from the strategies that Frank applies in his efforts to handle the confusing situation and his aroused panic response. For instance, Frank felt angry about himself and the frustrating situation (Op't Eynde and Hannula, this issue). He later described by himself his internal talk at that moment: "come on what is this all about!!" With his returned self-confidence and efficiency Frank decided to use the strategy that he had also previously applied successfully. *By using this anger* as the force he redirected his attention toward the problem statements and persisted in his efforts to continue the solving process. He reported that he "just kept searching...". The conscious decisions, self-control and self-direction reflect Frank's more *active self-regulation of his affect* as well as behaviour. Active self-regulation and emerging personal agency also mean that panic and worry were not too powerful for Frank to overcome. This may be due to Frank's personality aspects (e.g., calm personality, high general self-regulatory skills), to his strong confidence with mathematics, and/or to the problem context that did not appear too unfamiliar or distressing to him. He was also a high achiever who likes mathematics and finds it important and interesting (Op't Eynde and Hannula, this issue). Both the reasonable environmental and mathematical context and these promotive aspects of Frank's stable mathematical self-systems (e.g., positive math value and competence beliefs) helped his efforts and ability to actively regulate his arousals, responses and behaviours during solving the problem (Malmivuori, 2001). And, Frank's active self-regulation (conscious intentions, decisions, control) of affective responses and solving processes had decisive role in his effort and success with the subtaks 2. Finally, Frank's emerging personal agency and happiness after finishing succesfully with the problem reflect important positive experiences of the self with mathematics. I suggest that positive self-experiences with efficient self-regulation and personal agency will influence the further construction of Frank's promotive self-systems in learning mathematics.

4. DISCUSSION

In this paper, I have focused on students' self-systems and self-system processes for understanding the role and functioning of powerful affect in mathematical learning situations. This broader theoretical framework provides a basis for reinterpreting previous mathematics education research on affective factors, for going beyond the traditional static concepts, and for integrating the separate domains of affect, cognition and behaviours. Ongoing self-appraisals and self-regulation are the key dynamic determinants in these self-system processes of students' affective experiences and mathematics learning. Moreover, we suggest that such features as high personal agency with high self-awareness, positive self-appraisals and efficient self-regulation will empower students' mathematics learning and problem / processess solving, e.g. to consciously act on debilitating affective responses. They may then choose to 'fine tune' the role of their affective responses in learning and problem solving processes.

Above I illustrated the interdependencies between students' self-appraisals, affective responses and self-regulation, using both quantitative results and Frank's case. Both datasets indicated the significant role of self-confidence and affective responses in self-regulation of mathematics learning or problem solving. In studying stable self-systems, mathematical self-confidence correlated to powerful negative and positive affective responses. Both were further linked to self-regulatory patterns, and to some extent to math performance. High self-efficacy and positive affective responses were positively linked to promotive self-regulatory patterns of persistence and preference for challenge in mathematics. Instead, low self-esteem and math anxiety were negatively related to these patterns and mathematics performance. The relations to the self-regulatory patterns were stronger for the positive responses and general fear of mathematics than for mathematics self-confidence, indicating close interrelations between powerful affect and self-regulation. The self-regulatory patterns of the study were few and reflected motivational aspects more than e.g. use of specific metacognitive strategies in solving problems. However, the quantitative results showed important aspects of students' self-systems in mathematics. Self-system processes were again illustrated by Frank's situation-specific appraisals, affective responses and self-regulatory activity. Frank's case (analysed also by other authors of this issue) offered a more detailed picture of the role of affect in self-regulation during problem solving. Especially, the case and above interpretations displayed the effect of active self-regulation of affective responses on problem solving.

In this perspective we stress the co-constructive and dynamic nature of affect and cognition, in which the functioning of self-appraisals and self-regulation ultimately determine the role of affect in students' mathematical learning or performance processes. This viewpoint also helps to deal with the complexity of affect-cognition interplay in learning situations. It supports the idea of personally and situationally unique affective experiences and, hence, is consistent with socio-constructive approach presented by Op't Eynde and his colleagues. My notions of self-system processes with affect, metalevel processes and self-regulation at different levels of self-awareness are consistent with mathematics education research results indicating the relations between students' self-perceptions, powerful affect, and mathematical behaviours. They relate also to ideas like meta-affect (affect about affect) introduced by DeBellis and Goldin. Furthermore, we consider that linking affective experience to mental, behavioural and regulatory processes at different levels of consciousness will connect affect, cognition and behaviour closer to each other. Taking account of different levels of self-awareness (in automatic vs. active regulation of affect) connects this perspective to concepts of embodied cognition and affect considered by Brown and Reid or to psychoanalytic approaches to affect used by Evans et al. I did not discuss in detail students' personal goals, goal construction or goal regulation considered as important in recent research on motivation and studied also by Hannula in this issue. These represent important self-directive constructions and processes (i.e. features of self-regulation) in students' mathematics learning, behaviour and affective experiences. More profoundly, we link personal goals in mathematics learning and self-regulation to concepts like personal will or self-motivation (Malmivuori, 2001).

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