WHY IS THERE NOT ENOUGH FUSS ABOUT AFFECT AND META-AFFECT AMONG MATHEMATICS TEACHERS[1]?

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The role of affect in the teaching and learning of mathematics is widely recognised by researchers in the field of mathematics education, and a plethora of literature has been published on the subject. However, the related issue of meta-affect has been addressed only minimally. This paper aims to increase awareness of its importance within the community of mathematics teachers and mathematics teacher trainers. More specifically, it suggests how a meta-affective approach may be usefully adopted by mathematics teachers in the classroom as well to catalyse the personal and professional growth of current or future mathematics teachers.

Keywords: affect, awareness, belief, emotion, meta-affect.

Introduction

The realm of affect is an especially rich area of research in mathematics education. However, the impressive scientific achievements in both qualitative and quantitative terms have failed to adequately influence practice among mathematics teachers or moreover, to drive investigation into the application of scientific research to practical mathematics instruction in the classroom. To no avail, Burkhardt and Schoenfeld (2003) invited researchers to "make progress on fundamental problems of practice". With twenty-five years of experience imparting in-service training for mathematics teachers and ten years of experience as a mathematics teacher trainer (in Italy a two-year postgraduate degree leading to teacher certification was launched ten years ago), the author has investigated the relationship between affect, meta-affect and changes in teaching practice among mathematics teachers. The adoption of a teaching methodology based on the resulting experience would appear to offer considerable promise.

Theoretical framework

McLeod (1992) identified beliefs, attitudes and emotions as the constructs upon which affect regarding mathematics is based. De Bellis & Goldin (1997) also recognised the role of values in this sense. Research into affect has evolved considerably since then, with growing investigation into the issues involved and a broadening of the theoretical background, to the point where multiple theoretical frameworks have emerged. We may thus address affect as a system of representation and communication (Goldin, 2002) in which beliefs, attitudes, emotion and values – the four elements in Goldin's *"tetrahedral model"*- are viewed as a sub-domain; as a

[1] The author hopes the title doesn't sound disrespectful to Schoenfeld (Schoenfeld, A. H.(1987). What's all the fuss about metacognition?. In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189-215). Hillsdale, NJ: Lawrence Erlbaum Associates), who wrote the paper in question when asked to explain 'metacognition'.

system "strongly, naturally and in a dynamical way" linked to cognition (Malmivuori, 2004); within a socio-constructivist framework (Op 't Eynde, 2004) or with an embodied cognition approach (Brown & Reid, 2004). The various theoretical frameworks highlight two elements which should attract the attention of researchers. The first of these regards the frequent appearance of the terms 'metacognition', 'consciousness', 'awareness', 'self-awareness' and 'meta-level' in relevant literature. An important step in developing the debate and research field would be taken by investigating the meta-levels of the four constructs, their theoretical collocation and their correlations with metacognition. Hannula (2001) offered an approach to the issue, but there remains much more to be learned. The importance of metacognition in the learning processes was first highlighted by Flavell (1976). LeDoux (1998) and Damasio (1999), by conducting investigations based on fMRI (functional Magnetic Resonance Imagining), CAT (Computerized Axial Tomography) and PET (Positron Emission Tomography), have demonstrated that the functioning of the cognitive and emotive systems are closely related. In light of these studies one might plausibly wonder whether the term metacognition still means anything, or what its role might be within the new scientific framework. Must it be accompanied by the term meta-emotion, must a new term be coined to comprise the two, or must yet other terms be coined? The second element to emerge from the theoretical frameworks of affect is how consistently they display links between affect and neuroscientific research (Schlöglmann, 2003). This has made it possible to create a neuroscientific basis for the interdependence of affect's four constructs, so frequently emphasized in research. It has also afforded clarification of other hotly contested issues, such as the nature of beliefs, which must necessarily be hybrid (i.e.Furinghetti & Pehkonen, 2002): that is, both cognitive and emotive. This supports author's hypothesis (Moscucci, 2007) beliefs are the 'best' element, among the four constructs of affect, which to act on, and this is the reason why, in this contest, the author is particularly interesting in 'beliefs', which seem, together with emotions, to shape attitudes (Hart, 1989). The matter of defining 'belief' remains unresolved within the research field. Hence, here the term 'belief' will be taken to represent some sort of 'primitive entity', and every belief some sort of 'axiom' assumed as a result of personal experience; basically an affirmation which is accepted without proof. Furthermore, different mathematics-related belief systems (Schoenfeld, 1992; Leder, Pehkonen & Törner, 2002) are in some way all correlated. So we might say, by adopting terminology from algebraic structure language, that the individual's beliefs regarding mathematics (although the choice of subject is inconsequential) do not make up a 'set' of beliefs but rather a 'structure' of beliefs. Researchers have not simply investigated the role of student beliefs in their learning processes, but also the role of the beliefs of mathematics teachers. As regards definitions, Richardson (1996) identifies teacher beliefs with their theoretical perspective of teaching methodology. This underlines the effect of teachers' beliefs on their teaching practices. It would seem logical to deduce that teachers' beliefs determine the quality of their practices (Cooney, 2001). However, almost twenty years ago, Cobb, Wood and Yackel (1990) noted that these influence each other reciprocally, rather than in terms of 'side of the implication'. The interrelations among teacher beliefs and student beliefs are equally complex and controversial (Beswick, 2005) and it appears currently impossible to hypothesize the entity of these relations, given that student beliefs have not been proven to be the product of teacher beliefs, nor *vice versa*. Nevertheless, although the theoretical issue has not been resolved, the impact of belief systems on the classroom behaviour of teachers has been recognised in numerous studies involving mathematics teachers (for instance, Pehkonen, 1994; Chapman, 1997, 1999).

From the realm of theory to didactic practice

As mentioned in the introduction, this proliferance of scientific research has failed to produce significant developments that may be of direct use to mathematics teachers in the classroom. And yet, such developments are sorely needed by mathematics teachers, students, school systems and indeed society in general. Thus any efforts to impact on the belief systems of teachers, and especially on any beliefs that are damaging to students, are more than welcome. Damaging ideas might be identified as 'inefficacy beliefs' (*e.g.*"A special inclination is needed to be good at maths in school"), in contrast with 'efficacy beliefs' in teaching mathematics, which have been investigated and illustrated (Philippou and Christou, 1998; 2002). The question to be answered is how to progress from inefficacy beliefs to efficacy beliefs and efficacy teaching practices. An approach addressing meta-affect may well prove useful. Goldin (2002) considers meta-affect as a key construct, "including affect about affect, affect about and within cognition that may be again about affect, monitoring of affect, and affect as monitoring". The potential of meta-affect as a vehicle for the development of the professional profile of mathematics teachers has been confirmed throughout ten years of successful[2] mathematics teacher training carried out by the author with teachers undergoing training and already in service. Due to space restrictions, only in-service teachers will be considered here.

Towards a holistic approach to maths teachers affect

Fifteen or so years of training courses proved that, in spite of apparent success, the impact on classroom practice was undeniably disappointing, with the didactic practices of the teacher participants evolving only rarely. Few teachers could bear the prospect of giving up the "school mathematics tradition" (Cobb et al., 1992) (frontal lessons aimed at the introduction of the new technique, presentation of examples and setting of exercises), even if the main goal of the courses was precisely didactic quality. Indeed, within the Italian school system the proportion of failures in mathematics with respect to all academic subjects has been and continues to be

[2] Training is reputed successful when: 1) the participating teachers express their satisfaction with the training by means of their responses to a survey presenting questions in a 4-point Likert scale format; 2) the participating teachers begin to modify their teaching practices as suggested during the training course; 3) the modification of classroom practices by teachers produces positive effects (in the sense that the students benefit both in terms of their affect toward mathematics and their actual performance in this discipline).

telling: the Ministry sets this year's figure at 42%. Moreover, the 'discomfort' (lack of success but also, for instance, 'negative' emotions and 'inefficacy' beliefs towards maths) of Italians with mathematics was believed (and subsequently proven (Moscucci et al. 2005) to be an 'endogenous cause' (*e.g.* arising within the school system itself) of student dropouts. This alarming situation called for the creation of an intervention scheme based on the following principles: 1) teaching methodology and teacher affect are closely linked (this was contextualized above from a theoretical perspective); 2) dealing with beliefs as a purely psychological construct is limiting, as mathematics teachers work together with their colleagues within a social context that tends to perpetrate traditional, time-tested teaching techniques (Op 't Eynde, 2004); to consequently avoid marginalising teachers who attempt to update their approaches, the teacher educator needs to undertake group work as has been carried out during well-documented experimentation (Jaworski, 2003); 3) the teacher trainer must obviously make use of the same didactic methods that are presented to the teachers for use with their students. The outcome of these considerations was the creation of an intervention scheme (Moscucci, 2007), in which beliefs systems role was highlighted. Meantime, the author has understood the synergy springing out the contemporaneous work about emotions and beliefs. As has been repeatedly debated within the theoretical framework, the affect of an individual (be it a student or teacher) is a complex structure comprising closely-linked constructs. Therefore any effort to influence it must simultaneously address all the elements on which it is based. So, perhaps, the success of that intervention scheme is due to the global – we would say 'holistic' – approach to teacher affect.

Meta-affect: a 'tool' not enough used by mathematics teachers?

About thirty years have passed since Flavell (1976; 1979) published his metacognition research and the importance of this concept to the learning process has been proven and reported (for instance, Hartman (1998)). However, it is rare to meet mathematics teachers who make use of didactic techniques informed by the abundance of metacognition research. The big step in the field of metacognition might involve equipping maths teachers with tools of observation and intervention that could be applied first and foremost to themselves: "...increasing metacognitive activity through private reflection and shared conversations increases teachers' awareness of their subjective knowledge… beliefs are often challenged through this process, which lays the groundwork for the construction of new knowledge and for real change in teaching practice" (Hart, 2002). The training courses for mathematics teachers conducted by the author over the last ten years were structured by means of a method (Moscucci, 2007) that seeks to achieve meta-affective goals with the teachers prior to addressing discipline-specific issues. The distinguishing characteristic of this method is its emphasis on awareness (Marton & Booth, 1997): the teachers are put in a position to autonomously become aware of their own belief systems and emotions, without being obliged to openly declare their beliefs and emotions. There are two reasons for this. The first, as regards beliefs, is the well-known distinction between “beliefs espoused and beliefs in practice” (Schoenfeld, 1989). What’s more, teachers often are not conscious or even aware of the beliefs underlying their teaching practice. The second regards emotions. Awakening the emotions that have accompanied teachers during the development of their professional capacity is extremely beneficial. The emotions experienced almost certainly influence their beliefs regarding mathematics learning and teaching. Even memories of what it was like to be a maths student as far back as primary school need to be evoked. Remembering is the first step. Then the emotion recalled must be elaborated to try to analyse its immediate impact and understand any eventual lasting repercussions. This means engaging teachers in ‘meta-emotive’ activity without attempting to place educators in the role of psychologist, but rather assisting teachers to self-analyse their memories. Let us briefly examine the close link between meta-emotion, meta-cognition and the awareness of beliefs. Emotion[3] is a personal response to an event signalled by physical symptoms such as an accelerated heart rate, blushing and facial expression. With time (a matter of seconds or minutes) these symptoms lessen and eventually disappear. There is consciousness of the emotion, but awareness takes hold only as the intensity of the physical reaction diminishes and it again becomes possible to ‘think rationally’, as we say. If the emotion has been particularly intense or is part of a series of emotions related to a single situation (such as learning mathematics), it begins to generate thoughts regarding the emotion’s cause, origins, consequences and responsibilities. These spontaneous or subsequent thoughts may set off a chain of further thoughts as well as further emotions. The initial emotion and its related physical manifestations have only short-term effects, thus failing to directly influence an individual’s future. However, the resulting chain of thoughts and emotions may lead to the creation of certain beliefs that are known to be highly influential. Most beliefs are generated in this way. Thus awareness of this process is a fundamental step in controlling negative emotions, neutralising their impact on the present and re-elaborating the beliefs generated by them. When considering this process, a distinction must be made between maths teachers with a mathematics degree and those with a different degree (in Italy this is not only possible but predominantly the case with teachers of the grade 6-9 levels). With this latter group a greater effort must be dedicated to developing awareness of emotions**,** as such teachers often experienced difficulty with mathematics, as student, at school or at university. As also regards teacher attitudes, activities that develop awareness of them must be provided, and teachers can be left free to define ‘attitude’ as they wish. Awareness of one’s attitudes is intended as awareness of what teachers consider to be their attitudes toward mathematics both as a learner in the past and as a teacher presently. To give an example, the following activity frequently proves useful. Teachers are asked to put down in writing – informally, without attention to composition – how they perceive their attitudes. Then their students are asked to repeat the exercise anonymously by the researcher - trainer. The students may find it

[3] When especially intense, the amygdale may come into play (LeDoux, 1995).

easier to express their opinions if they are provided with a guideline such as the beginnings of sentences to complete. The teachers observe the opinions expressed by their students and, following a personal analysis, are asked to put in writing their comments regarding both their and their students' tasks. As this brief description illustrates, this approach concentrates on beliefs and emotions, inasmuch as they are considered to shape attitudes, as underlined in the theoretical framework. The aim of this approach is to create a virtuous cycle between the re-elaboration of beliefs and emotions on one hand, and the adoption of non-traditional methods on the other (the non-traditional methods are, in certain cases, 'discovered' by the teachers in a socio-constructivist learning environment, in other cases by questioning their classroom practices). The first feeble attempts to make use of new methodologies and non-traditional disciplinary approaches produce initial resources that encourage teachers to progress in their development. The teachers begin to experience new emotions, thus they re-elaborate their beliefs, and recontextualise their previous emotions. This is how the virtuous cycle is catalysed. The awareness of one's own awareness represents another step toward quality in a teacher's meta-affective competence.

A short description of one experience

Of many cases observed, the following - chosen to give a 'hint'- offers elements to ponder as far as different teacher typologies are concerned. In 2005 the author was invited by the principal of a vocational school to set up and implement a three-year project aimed at reducing student failures in mathematics, which regarded over 60% of students (official data provided by the School Administration). The situation was in line with that of all schools of this kind, so it was actually no worse than average. Due to the lack of space, it is impossible to describe the details of the project. Briefly, it consisted in conducting activities based on meta-affect, as described in the previous section. The author worked with the teachers and the teachers worked with their students. As for subject teaching, the teachers were required to 'embrace' a socio-constructivist teaching methodology. The author personally met the students with special difficulties (three-four times -two hours- for each class involved) in order to diagnose their nature. The school's three mathematics teachers -all of them- were more or less of the same age, between forty and forty-five, while their psychological and professional profiles varied. One teacher, who will be called Victoria, was very cordial and outgoing, had a degree in mathematics, attended mathematics teaching conferences regularly, had previously participated in various innovative mathematics teaching projects and had always attempted to put into practice the developments presented in mathematics teaching journals. In spite of her efforts to improve her students' results, she had never been successful. She participated in the project with great expectations. Another teacher, who will be called Angela, had a degree in mathematics and was disappointed by the poor results and scarce interest of her students, to the point where she simply wanted to retire. Angela was more insecure than Victoria but sincerely wanted to help her students. Perhaps it was a sense of impotence that made her want to retire. Although without great hopes, she participated in the project willingly. The third teacher, who will be called Bill, had a degree in IT and had taken the teaching job following a frustrating experience as an IT technician. He had acquired a reputation for strictness with the students. He commented that “his students didn’t work enough” or “lacked the basics”, and that “some of them simply couldn’t be helped”. He participated in the project only following the insistence of the principal. As questions came up during the initial meetings (What is the role of school in educating individuals? And what is the role of mathematics? What is ‘school mathematics’?), his interest seemed to grow. “The answers to certain questions should be obvious to a teacher while they may not be; most answers are simply rhetorical!”. The three teachers attended an introductory course (about 30 hours, as a whole), using the intervention scheme mentioned in the previous paragraph (Moscucci, 2007), during the month of September 2005, prior to the beginning of the school year. They worked as usual together with their mathematics-teaching colleagues, but in an atmosphere of “contrived collegiality” (Hargreaves, 2004), while in this new context they began to appreciate the value of ‘collaborative work’, undoubtedly benefiting from collaboration in “small groups”, as underlined by Santos (2007). They used the same methodology with their first -and second- year classes (involving more than 150 students). Throughout the year their work in class was supported by means of meetings with the author, every two weeks during the first three months of the year, later monthly, as well as long phone calls to provide emergency help. The author decided not to attend teachers’ lessons not to intrude a ‘strange’ element in the ‘classroom ambience’ and it was impossible to organize recording tools (but author’s meeting with the students in special difficulties). Unbeknown to the teachers and the author, the project was monitored by the principal through inspection of the attendance registers. At the end of the first school semester, appreciable improvements were noticed of the average final marks for the same level classes with respect to preceding years (data, and the following ones, from the Minutes of Class Meetings). The only change undertaken regarded the teaching methodology introduced in the project, so it is ‘highly’ likely that this was precisely the reason of these improvements. Victoria and Angela’s classes proved to be the most successful in the project, as, at the end of the first year, the number of failures in mathematics was reduced by about 90%. Angela also regained enthusiasm in her teaching. Bill encountered greater difficulty than his colleagues in applying the initial methodology focussing on meta-affect and the subsequent content methodology: while Victoria and Angela showed their enthusiasm for the activities suggested by the author, Bill always needed additional time to accept the proposals, and, above all, he was hesitant to update the activities in his classes. In any case his students achieved much better results with respect to previous years. Even if each teacher made up their own test, they were very similar except for insignificant details. Overall, at the end of the project’s first year, the only students to fail mathematics had also failed most other subjects and consequently had to make up the year. At the end of the year the school’s vice principal conducted a school-wide survey (completely unrelated to the project), and the results showed mathematics to be the students’ favourite subject. Undoubtedly the aspect of the project regarding course content played a part in the project's success, but it would have been impossible to even address course content without first eliminating the negative preconceptions towards mathematics of most students. In the third year of the project Victoria was transferred to a scientific high school renowned for its strictness and traditional methodology. The classes she adopted the method with achieved better results than all the other classes of the same year on a standardized test administered to all. In the last year of the project Angela suffered the lack of (mostly psychological) support from Victoria and lost some enthusiasm, but is still convinced of the method's validity. Bill seems to have become less strict and perseveres in trying to apply the method. The author has obtained such surprising outcomes as those described in this paper on many other occasions. Now she is planning to monitor wider experimentation in a vocational school. At present it seems important, at first, to spread a research hypothesis: the awareness of one's own belief systems accompanied by a personal reworking of the emotions felt during mathematics tasks, may be key in removing 'inefficacy beliefs' and 'recontextualising' past emotions so that they are innocuous in the present. Secondly, the author hopes other researchers, teacher trainers and teachers will try to adopt these teaching methods and schema so as to confirm or contrast the hypothesis.

Remarks

The positions of numerous researchers on meta-affect recognising its central role in affect, the relationship between meta-affect and metacognition revealed by neuroscientific research and the success of certain teaching methods based on meta-affective methodology should encourage researchers to investigate this subject from a theoretical perspective. After all, like many fields of education science, mathematics education displays distinct characteristics. In disciplines such as medicine or pharmacology, before a treatment such as pharmacological therapy can be applied, various levels of experimentation must be carried out. Instead, in the field of education it is possible and often especially effective to alternate research and the application of research outcomes to practice. Or better, this is a very fruitful way to proceed. This makes it particularly important to spread the use of practices with a high potential for success. The resulting discussion, rebuttal and development can only contribute to furthering research and increasing didactic quality.

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