Primary teachers' affect: a crucial variable in the teaching of mathematics

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Mathematics education is strongly interested in defining "what is necessary for teaching mathematics effectively". The main directions of research emphasize the cognitive side of the answer to this question, trying to describe what kind of knowledge is needed in order to teach mathematics effectively. Starting from the point that teachers' affect plays a crucial role in determining the quality of teaching, we discuss this issue from a theoretical point of view, introducing the construct of "attitude towards mathematics teaching". Within this theoretical framework we conducted a study with 189 primary school pre-service teachers, investigating teachers' emotions, beliefs and attitudes. In this paper, we analyze and discuss the relationship among the participants' emotional disposition towards mathematics and towards the idea of having to teach it, their past experiences as math-students and the current perceived competence in mathematics.

Although the teacher is obviously a central player in the mathematics teaching-learning process, research in mathematics education has focused its attention on teacher education rather recently: mathematics teacher education is considered "an emerging field" (Adler et al., 2005).

A central point in this emerging field seems to be the need of a deep reflection about "what is necessary for teaching mathematics effectively". In this direction, a great contribute comes from the work of the educational psychologist Shulman. In 1986, Shulman developed his very famous perspective that recognized three different components of knowledge necessary for teaching: Curricular Knowledge (CK), Subject Matter Knowledge (SMK) and Pedagogical Content Knowledge (PCK). PCK represented the real innovation: a knowledge "which goes beyond

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knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (Shulman, 1986, p. 9).

Shulman's perspective has had a great impact on the research about teachers in mathematics education, having inspired many important studies in the field. For example, Ball and Bass (2003) explicitly referred to Shulman's work in the development of their theory of Mathematical knowledge for teaching (MKT), emphasizing the link between improvement of students' learning and improvement of teachers' knowledge:

> We seek in the end to improve students' learning of mathematics [...]. We focus on teacher knowledge based on the working assumption that [...] the goal of improving students' learning depends on improving teachers' knowledge [...]. The problem: what mathematics do teachers need to know to teach effectively? (Ball & Bass, p. 3)

The work of Ball and Bass has had a major influence in the field of mathematics education and it is surely very thorough and interesting. Nevertheless, Ball and Bass's perspective about mathematics teacher development is limited exclusively to the cognitive aspect.

In what may be considered the initial manifesto of the modern research on affective factors in mathematics education, McLeod (1992, p 575) underlined: "all research in mathematics education can be strengthened if researchers will integrate affective issues into studies of cognition and instruction". In particular, for what concerns the question "what is necessary for teaching mathematics effectively", our view is that the answer cannot be limited to what teachers know and that it must include considerations about what teachers believe and feel.

According to Zembylas (2005, p. 467, emphasis as in original):

> Teacher knowledge is located in "the lived lives of teachers, in the values, beliefs, and deep convictions enacted in practice, in the social context that encloses such practices, and in the social relationship that enliven the teaching and learning encounter". These values, beliefs *and emotions* come into play as teachers make decisions, act and reflect on the different purposes, methods and meanings of teaching.

According to this framework, as researchers, but also as mathematics educators we are interested in studying teachers' beliefs, emotions and attitudes towards mathematics and towards its teaching in order to support teachers' professional development. In this perspective, we have conducted a study to investigate affective factors of 189 future primary school teachers and to recognize the relationships among these factors. In this paper we analyze and discuss the answers to four questions of the questionnaire we used as tool, in order to describe the relationship among the

participants' emotional dispositions (towards mathematics and towards the idea of having to teach it), their past experiences as math-student and their current perceived competence in mathematics.

Teachers' affect: theoretical framework

Since the early research in the field of affect, the interest about teachers' beliefs, emotions and attitudes in mathematics is mainly motivated by the conviction that these factors influence teachers' practice and then strongly affect the quality of students' learning in mathematics: "the teacher's attitude is a potent force in the classroom" (Burton, 1979, p. 131).

Initially the focus of the research was placed on finding – through quantitative studies – cause-effect relationships between affective factors held by a teacher and his/her classroom practice. This approach is problematic and leads to inconsistent or even contradictory results: for example the problem of the inconsistency between beliefs professed by teachers and their practice is well-known (Di Martino & Sabena, 2010).

In the nineties, the research on affect in mathematics education developed through a shift from a normative-positivistic paradigm, to an interpretative one (Zan et al., 2006). A gradual affirmation of the interpretative paradigm in social sciences, related to a greater attention towards aspects of the complexity of human behavior, has led researchers in mathematics education to abandon the attempt of explaining behavior through measurements or general rules based on a cause-effect scheme, and to search for new interpretations. After this change of paradigm, there was a growing awareness among mathematics educators of the central role of affect in mathematics learning and teaching (Tsamir & Tirosh, 2009). But, as Philipp (2007, p. 309) underlines, there is a great imbalance between research on teachers' beliefs, and research on teachers' emotions:

> One noteworthy difference between research on teachers' beliefs and affect is that whereas research on teachers' beliefs has been extensive and subsumed into almost all areas of research on mathematics teaching and learning, the study of teachers' affect has not.

Actually, this imbalance is not peculiar only to mathematics education:

> Despite the enormous blossoming of psychological research on emotions since the early 1980s, little of this work has informed current research on teachers [...]. Researchers also know little about how teachers regulate their emotions, the relationship between teachers' emotions and motivation, and how integral emotional experiences are in teacher development. (Sutton & Wheatley, 2003, p. 328)

The research about teachers' emotions in mathematics education has mainly focused on primary pre-service teachers, in particular studying and well-documenting the problem of primary teachers' negative emotions (anxiety, fear, etc.) towards mathematics (Wood, 1987; Hannula et al., 2007; Di Martino & Sabena, 2011). Many researchers stress the importance of preventing or overcoming these negative emotions as a necessary condition to improve the quality of mathematical learning. Already in 1978, Mihalko underlined the point that teachers are part of the cycle of "mathophobia":

> [Mathematics teachers] cannot be expected to generate enthusiasm and excitement for a subject for which they have fear and anxiety. If the cycle of mathophobia is to be broken, it must be broken in the teacher education institution. (Mihalko, 1978, p. 36)

Our conviction is that interpreting (and counteracting) the phenomenon called mathophobia needs to consider teachers' affect in its entirety. From this point of view, if Philipp (2007) stresses the complete lack of integration between the research on teachers' emotions and the research on teachers' beliefs, many scholars give theoretical emphasis to the strong relationship between beliefs and emotions (Hannula, 2009).

Di Martino and Zan (2010; 2011) consider this relationship at the basis of their three-dimensional model of attitude (TMA model, see figure 1). In their view, attitude towards mathematics is characterized by three strictly interrelated dimensions: emotional disposition towards mathematics, view of mathematics and perceived competence in mathematics.

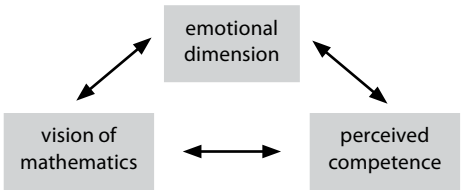

Figure 1. *The three-dimensional model of attitude (Di Martino & Zan, 2010)*

Within the interpretative paradigm, Di Martino and Zan's theoretical research fits with the strong incentive "to develop constructs that might be applied to help make sense of teaching and learning environments" (Philipp, 2007, p. 264). In this paradigm the single affective construct is no longer a trait of the observed subject, predictive for his/her behaviors, but instead it is a model of the observer, useful to interpret and understand processes of teaching and learning (Ruffel et al., 1998).

In this framework, research in mathematics education has underlined that to analyze teachers' affect it is necessary to consider not only their attitude towards mathematics but also towards its teaching (Relich, Way & Martin, 1994, p. 56).

According to this view, we have extended the model of attitude, considering also teacher's emotional disposition, view and perceived competence towards mathematics teaching. We conducted a study focused on primary pre-service teachers' attitude towards mathematics and its teaching. The study has a twofold goal: on the one hand – as teachers' educators – to help future teachers becoming aware of the attitudes that they hold (it is the first step towards an eventual change), on the other hand – as researchers – to investigate the six dimensions involved in attitude towards mathematics and attitude towards its teaching and their mutual relationships.

In the Italian context, as discussed in a previous study (Di Martino & Sabena, 2011), primary pre-service teachers have often very negative emotions towards mathematics: for this reason, it appears to be important to investigate the nature and the origin of pre-service teachers' emotions towards mathematics and towards the idea of having to teach it.

Coherently with the described theoretical framework, the investigation about the nature and the origin of teachers' emotions leads to consider different aspects: the dimensions included in the TMA-model and the past experiences with math of pre-service teachers.

In this paper, we analyze similarities and differences between professed emotions towards mathematics and towards the idea of having to teach it, discussing the influence of the past experiences as math-students and the role of the perceived competence in teaching mathematics.

Methodology

Participants

The participants in our survey were 189 future primary school teachers, enrolled in the first year of the University degree for primary school teachers, in two different Italian universities: a small university in the south (37 pre-service teachers) and a bigger one in the north (152 pre-service teachers). All the participants were enrolled in the courses on mathematics and its teaching that took place during the first semester of the academic year 2011–2012.

Tool

In order to investigate about attitude towards mathematics and towards the idea of having to teach mathematics, we developed an open questionnaire on the basis of the evaluation of the results gained by previous researches with primary pre-service teachers using questionnaires (Di Martino & Sabena, 2010, 2011). The choice of an open questionnaire is not neutral: it depends, as many choices that remain implicit, on the researchers' values, beliefs and emotions (Zan & Di Martino, 2003). In particular we strongly believe that:

> It is open-ended responses that might contain the "germs" of information that otherwise might not have been caught in the questionnaire [...]. An open-ended question can catch the authenticity, richness, depth of response, honesty and candor which are the hallmarks of qualitative data. (Cohen et al., 2007, p. 249)

The variety of possible answers coming from open questions is a richness for research on affective factors and this richness is an irreplaceable value for the purpose of our study. Nevertheless we are well aware that open-ended questions have their limitations too, for example they are still one-way when compared with interviews.

The questionnaire was administered in the very first lesson of the course at both the Universities. Respondents were asked to answer anonymously (providing a nickname), in order to leave them free to describe their real thoughts and feelings towards mathematics and its teaching. The used questionnaire is composed by 12 questions focused on the three components of attitude (according to the TMA model), declined along the two dimensions of mathematics and its teaching. The questions can be organized into the six resulting factors as showed in table 1.

The questionnaire is oriented to capture relationships and dynamics developing over time. In particular, we were interested in seizing links between the past experience as students (e.g. Q5[1]) and the perspective towards the future teaching (Q10, Q11, Q12). Present is of course pervasive, since every answer is filtered by the subjects' present views, self-perceptions and emotions.

Methodology of analysis

As we have already said, in this paper we discuss only the answers to four questions of the questionnaire. In particular, we focus the attention on the respondents' emotional dispositions towards mathematics (the answers to Q4) and towards its teaching (the answers to Q10), trying to highlight the relationship of these emotional dispositions with

Table 1. *The questionnaire questions' categorization according to the developed model*

	Mathematics	Mathematics teaching
Emotional disposition	4. Write 3 emotions you associate to the word "mathematics". 5. How was your relationship with maths as a student? [Positive / Negative / Indifferent / Ups and downs] Explain why you think that your relationship was so.	10. Which emotions do you feel in knowing that you will have to teach mathematics? Why?
View	1. Write 3 adjectives you associate to the word "mathematics". 2. What is, in your opinion, a positive feature of maths? Why do you think so? 3. What is, in your opinion, a negative feature of maths? Why do you think so? 6. Indicate three qualities you consider necessary in order to succeed in maths. 8. For which reasons, in your opinion, can students have bad results in maths? 9. In your opinion, why is it important that mathematics is taught at school?	12. Which characteristics should have in your opinion, a "good" mathematics teacher?
Perceived competence	7. In which measure do you think to have the qualities written in the previous answer?	11. Try to describe some difficulties you expect to meet in teaching mathematics.

the respondents' past experiences as math-students (Q5) and with their current perceived competence in mathematics teaching (Q11).

Emotions are not linguistic things. Nevertheless, as Ortony et al. (1988) suggest, the most readily available non-phenomenal access we have to them is through language and we are willing to treat people's reports of their emotions as valid.

Regarding the methodology of analysis, descriptive statistics was used as an analytical tool to gain insights into the data. Dubar & Demaziere (1998) proposed an approach, called analytical, in order to systematically produce sense from people's words. Final outcome of this analytical process is the construction of a set of categories, properties, and relationships.

In order to construct the categories, an inductive content analysis was carried out (Patton, 2002): the procedure required a segmentation of the collected data (in our case, the answers to a single question) in semantic units. Then, lexical units referring to the same theme or argument were classified in semantic units called topics. Subsequently the frequencies of the lexical units in the topics were evaluated. From this analysis some main topics (categories) appeared.

For the classification of the labels used by the respondents to describe the emotional dispositions, we referred to the work about the cognitive

origin of the emotions (Ortony, Clore & Collins, 1988): emotions are described as "valenced reactions" to consequences of events, action of agents, or aspects of objects. Then we can classify the first class of reactions (to events) in being pleased and displeased, the second class of reactions (to agents) in approving and disapproving, and the latter (to objects) in liking and disliking.

We use these dichotomies for a first rough classification into positive/negative emotions in the analysis of the answers to Question 4 and Question 10. Nevertheless we agree with Ortony, Clore and Collins's (1988, p. 12) view in saying:

> An analysis of emotion must go beyond differentiating positive from negative emotions to give a systematic account of the qualitative differences among individual emotions such as fear, envy, anger, pride, relief, and admiration.

Results

The analysis of Q4 reveals a predominance of negative emotions, such as *anxiety*, *fear*, *panic*, elicited by mathematics with respect to the positive ones, like *satisfaction*, *enjoyment*, *curiosity*. This predominance emerges first in terms of numerical occurrence: the 28 % of the respondents expresses only negative emotions in his/her answers, while the 20 % expresses only positive emotions towards mathematics. Also in terms of the intensity of the declared emotions there is an imbalance: for example *panic* appears to be stronger than *curiosity* or *satisfaction*.

Q5 asks future teachers to give a judgment on their personal relationship with mathematics and to provide an explanation. Respondents can be divided into the four groups provided by the questionnaire: *Positive relationship* (PR: 23 %), *Negative relationship* (NR: 16 %), *Indifferent relationship* (IR: 1 %), and *Fluctuating relationship* (FR: 60 %). In this case,

Table 2. *Perceived causes for the relationship with maths*

Declared causes for the relationship with maths at school	
Positive relationship group (PR)	Negative relationship group (NR)
Teacher (60 %)	Teacher (52 %)
Innate characteristics (5 %)	Innate characteristics (40 %)
Success and its emotional consequences (23 %)	Failure and its emotional consequences (36 %)
Interest in the discipline (17 %)	Disinterest in the discipline (16 %)

no questionnaire is left unanswered. Moreover almost all the respondents provide detailed descriptions of their relationship with maths: the past relationship with mathematics appears something on which future teachers have much to tell. By a qualitative analysis of these rich answers we can categorize the perceived causes of such relationship (in some case the recognized causes are more than one). In particular, comparing the answers in the *extreme* groups (i.e. the PR and the NR) we obtain the data summarized in table 2.

Focusing on similarities and differences between the two columns of table 2 we observe that:

- in both groups the majority of respondents recognizes in one of their school teacher the main factor in the determination of their own relationship with maths at school;

- in the NR-group a great relevance is given also to attributed innate "limiting" characteristics. As an example, Elilee writes "Surely this is because I am limited and more inclined to the humanities". This aspect is little mentioned in the PR-group, roughly 5%;

- the relationship with mathematics is often identified also with the success or failure experiences and their emotional burden. This aspect appears strong both in the positive cases (for example, Minu writes: "I always liked the sense of satisfaction felt when I solve a problem") and in the negative ones (as an example June answers: "Besides my difficulty in following and understanding maths, a strong sense of anxiety has accompanied me every time there was a maths test in classroom"). This confirms that the emotional disposition and the perceived competence dimensions are deeply intertwined.

The analysis of Q5 provides insights on other dimensions of the TMA model. About view of mathematics teaching, respondents' narrative accounts shed light on what they consider good and bad qualities of mathematics teachers. Also some links emerge with the perceived competences in mathematics teaching.

Analyzing the answers to Q10 we observe that those respondents that are in PR-group (Q5) and declare positive emotions towards maths (Q4) declare also positive feelings towards the idea of having to teach maths.

In the case of negative relationship or negative emotional disposition towards mathematics, the correlation with emotional disposition towards its teaching is not unidirectional. As a matter of fact many respondents that declare negative emotions towards mathematics or a

negative relationship in the past with it display positive feelings regarding the perspective of having to teach it. Indeed the 40 % of the respondents declares a positive emotional disposition towards the idea having to teach mathematics whereas the 30 % of the respondents is scared by the same perspective.

In our opinion, it is very significant that the most used word in the answers to this question is: *responsibility*. In many cases, the difficulties met in the personal school experience are considered as the main stimulus for the future work, as we can read in several protocols such as the one of Nadi, who writes: "It is exciting to think that I might give children what had not been given to me". This kind of positive feeling is often reflected also on the kind of difficulties respondents think to have to overcome in teaching mathematics (Q11), so it is linked to the dimension of the perceived competence on mathematics teaching.

Nevertheless in other cases, the negative past experiences appear to be the origin of rooted and precise beliefs about mathematics teaching that have a negative influence on the perspective of teaching mathematics. These beliefs appear to be closely related with the view of mathematics teaching and with a low perceived competence towards the teaching of mathematics emerging from answers to Q5. Two main features emerge as crucial: on the one side the fear of being unable in helping the students to understand mathematics, at a *cognitive level*, as we can read, for example, in T90' protocol: "I am discouraged because I do not feel able to explain to a child topics as multiplication tables, division that I now consider routine"; on the other side the fear of being unable in conveying the love of doing maths, at an *affective level*, as we can read in the protocol of Cielo: "I feel anxiety because I might not be able to transmit the love for the subject".

As a matter of fact, some people with negative relationship with mathematics see in the perspective of teaching a possibility for *redeeming* themselves in their relationship with mathematics, whereas others, on the contrary, declare to feel insecure in accomplish a work that they consider important but difficult. Actually, almost all the respondents consider teaching of mathematics a very difficult challenge, but there is a clear distinction between those that see it as a stimulating challenge and those that see it as an insurmountable obstacle. In the latter case, strong negative emotions are elicited by the idea of having to teach mathematics. This remark highlights that negative feelings towards the perspective of having to teach maths are strongly influenced by a low perceived competence towards mathematics as, for example, it emerges from Nello's protocol: "Fear, because I have not the necessary basis of mathematics for teaching it". But the same negative feelings are also associated to a low

perceived competence towards mathematics teaching, as for example in RedQueen's protocol: "Fear, because I would like to transmit my passion to other people, but I fear not to find suitable methods to be effective".

Indeed, analysing the answers to Q11, many relationships with other components of the model emerge. The expected difficulties declared by the respondents were split, through the inductive content analysis carried out, into six categories.

Some of these categories are not totally separated, in the sense that in the answers belonging to a category there often are insights about other categories.

C1 – *Transmitting knowledge*. In the answers classified as belonging to this category, respondents declare to expect to have difficulties in "explain the subject", "to be clear", "transmitting their own knowledge in an adequate way", "using a suitable language", "help students to understand mathematics". Most of the respondents (54 %) gives answers of this kind. From the analysis it emerges a predominance of a "transmitting model" of teaching and a focus on its cognitive aspect. For example, from Bri's protocol it emerges the fear of "not to be able in explaining in an understandable way to others what I know I can transmit".

C2 – *View of mathematics*. In several answers to Q11 some relationships emerge with the "view of mathematics" dimension of the TMA model: 20 % of the respondents writes about difficulties related to their vision of mathematics. Many of them speak about the "abstractness" of mathematics as a trouble for the children: for example Baby11 writes: "the theoretical and abstract aspect of the subject, that gives the children troubles, because they are not yet able to master concepts that are not concrete".

This category is linked to the first one as we can see in some protocols like the one of Lele: "[...] since [mathematics] is a rigid discipline I believe that it is difficult to transmit it to the pupils".

C3 – *Students' knowledge and inclination*. The answers here are focused on future students. Respondents in this category (28 % of the whole) express concerns about "previous wrong knowledge" of the pupils, "prejudices of the future students towards mathematics" or "students that are ill-disposed (disinclined) towards mathematics". For example, in Stellina's protocol we read: "Mathematics is not well accepted by most of the students. So the first difficulty I will have to face is about this prejudice". Analogously ca92 is afraid of finding students already having "big difficulties, that do not engage themselves in overcoming those difficulties or that do not succeed in doing it".

C4 – *Emotional factors*. A link with the emotional disposition dimension comes out in the 26 % of the answers, belonging to a category which is centered on an affective dimension: respondents in this category declare to be afraid of "not involving future students", or of "making boring lessons".

C5 – *Didactical strategies*. The 14 % of the respondents speaks about difficulties related to didactics strategies aimed to involve all future pupils, without disregarding the ones with some specific difficulties.

Categories 4 and 5 are linked each other, as we can see from protocols like the one of Vale46 wishing "to find enjoyable methods to rouse pupils' interest in studying the subject and simple methods to explain it in a clear way".

C6 – *Low perceived competences*. Many difficulties future teachers expect to meet are linked to their low perceived competences: the 26 % of the participants declares to fear to have difficulties in teaching mathematics due to their low competences of the subject. As we already said, here a link between these two factors of the model strongly emerges. For example, Babsi writes that he/she fears to "find pupils more competent than me".

Most of the respondents influenced by low perceived competences (Q11) expresses negative feelings towards the idea of having to teach mathematics (Q10) and declares a fluctuating relationship with the subject as student (Q5). As an example Lalla, who declares "fear" towards the idea of teaching maths writes that a trouble for her would be that "pupils could perceive my awful relationship with the matter and model theirselves on me".

But in many other cases again what emerges is a chance of "redemption" and hope for future teaching, also when respondents declare a fluctuating past relationship with mathematics. As an example Piripolla, who expresses fear about "the language to use in order to be understandable for pupils" (Q11), declares a "fluctuating" relationship with mathematics (negative from a certain point onwards) (Q5) and affirms "to experience a strong emotion" towards the idea of having to teach maths, believing to "be able to explain [the subject] better than [my teachers] used to explain to me" (Q10).

Conclusions

As teacher educators we have a dual goal: a research goal that is to understand and recognize the most significant variables involved in the process of teachers' development and an educational goal that is to promote teachers' professional development.

These goals are clearly related and linked to the answer to the question "what do maths teachers need to teach effectively?".

Our perspective is that knowledge is only one side of the coin and that the affective sphere of math-teachers needs to be considered in the answer to the previous question. This is particularly true in the case of primary teachers, usually not specialized in mathematics: as a matter of facts, it exists a well-documented and alarming phenomenon of negative feelings towards mathematics and sometimes towards its teaching amongst primary pre and in-service teachers.

In Italy, primary school teachers' training is not specific for the different subjects and, in particular, there are only few courses regarding Mathematics. This situation can influence the expectations towards mathematics teaching both on a cognitive and on an affective side.

In this framework it is very crucial to develop theoretical and empirical studies in order to interpret this phenomenon and to recognize its causes. The deep knowledge of the phenomenon and the study of its effects on teachers' practice are the key to develop strategies to overcome difficult experiences and counteract the phenomenon itself.

Some interesting outcomes emerge by the analysis of pre-service teachers' answers to our questionnaire.

First, the awareness of the role of the school-teacher in their relationship with mathematics comes out as a fundamental topic. Another very significant issue coming from our analysis is the desire for math-redemption expressed by many respondents among those who declare negative past relationship with mathematics. This is a central point, because as teacher educators we have the chance of leveraging this desire to break the chain connecting the negative past school experiences with the negative feelings towards mathematics of many primary pre-service teachers. Moreover, our analysis suggests that the degree of confidence about the possibility of math-redemption is strictly linked to both cognitive aspects (PCK, SMK) and affective ones.

Mathematics teacher education is a quite recent field of research in mathematics education: the first *Handbook of mathematics teacher education* was published in 2008 by Sullivan and Wood. As we read in the preface of this handbook, "most research papers in mathematics teacher education put a major focus on the content dimension" and there is very little literature about teachers affect.

We are well-aware of the limitations of our study and of the need to strengthen and deepen our results, for example by using further and different methods of collecting qualitative data (e.g. interviews). We consider our study a first little step into the exploration of teachers' affect in its wholeness.

Thirty years after the famous paper by Schoenfeld (1983), we are convinced that there is the strong need to go beyond the purely cognitive also in the research about mathematics teacher education.

References

Adler J., Ball D., Krainer K., Lin F.L. & Novotna J. (2005). Reflections on an emerging field: researching mathematics teacher education. *Educational Studies in Mathematics*, 60, 359–381.

Ball, D. L. & Bass, H. (2003). Toward a practice-based theory of mathematical knowledge for teaching. In B. Davis & E. Simmt (Eds.), *Proceedings of the 2002 Canadian Mathematics Education Study Group* (p. 3–14). Edmonton: CMESG/GCEDM.

Burton, G. (1979). Comfortable with mathematics. *The Elementary School Journal*, 79 (3), 129–135.

Cohen, L., Manion, L. & Morrison, R. (2007). *Research methods in education*. London: RoutledgeFalmer.

Dubar, C. & Demazière, D. (1998). *Analyser les entretiens biographiques*. Paris: Nathan.

Di Martino, P. & Sabena, C. (2010). Teachers' beliefs: the problem of inconsistency with practice. In M. Pinto & T. Kawasaki (Eds.), *Proceedings of the 34th conference of the International Group for the Psychology of Mathematics Education* (vol. 2, 313–320). Belo Horizonte: PME.

Di Martino, P. & Sabena, C. (2011). Elementary pre-service teachers' emotions: shadows from the past to the future. In K. Kislenko (Ed.), *Current state of research on mathematical beliefs XVI* (89–105). Tallinn university.

Di Martino, P. & Zan, R. (2010). "Me and maths": towards a definition of attitude grounded on students' narratives. *Journal of Mathematics Teachers Education*, 13 (1), 27–48.

Di Martino, P. & Zan, R. (2011). Attitude towards mathematics: a bridge between beliefs and emotions. *ZDM, The International Journal on Mathematics Education*, 43 (4), 471–482.

Hannula, M. (2009). Affect in mathematical thinking and learning: towards integration of emotion, motivation and cognition. In J. Maaß & W. Schlöglmann (Eds.), *Beliefs and attitudes in mathematics education: new research results* (pp. 209–232). Rotterdam: Sense Publishers.

Hannula, M. S., Liljedahl, P., Kaasila, R., & Roesken, B. (2007). Researching relief of mathematics anxiety among pre-service elementary school teachers. In J.-H. Woo, H.-C. Lew, K.-S. Park & D.-Y. Seo (Eds.), *Proceedings of the 31st conference of the International Group for the Psychology of Mathematics Education* (vol. 1, 153–156). Seoul: PME.

McLeod, D. B. (1992). Research on affect in mathematics education: a reconceptualization. In D. A. Grouws (ed.), *Handbook of research on mathematics teaching and learning* (pp. 575–596). New York: Macmillan.

Mihalko, J. C. (1978). The answers to the prophets of doom: mathematics teacher education. In D. B. Aichele (Ed.), *Mathematics teacher education: critical issues and trends* (pp. 36–41). Washington: National Education Association.

Ortony, A., Clore, G. L. & Collins, A. (1988). *The cognitive structure of emotions*. Cambridge university press.

Patton, M. (2002). *Qualitative research and evaluation methods – 3rd edition*. London: Sage publications.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 257–315). Reston: NCTM.

Relich, J., Way, J. & Martin, A. (1994). Attitudes to teaching mathematics: further development of a measurement instrument. *Mathematics Education Research Journal*, 6, 56–69.

Ruffell, M., Mason J. & Allen B. (1998). Studying attitude to mathematics. *Educational Studies in Mathematics*, 35, 1–18.

Schoenfeld, A. (1983). Beyond the purely cognitive: belief systems, social cognitions, and metacognitions as driving forces in intellectual performances. *Cognitive Science*, 7, 329–363.

Shulman, L.S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher*, 15, 4–14.

Sullivan, P. & Wood, T. (Eds.) (2008). *Knowledge and beliefs in mathematics teaching and teaching development*. Rotterdam: Sense Publishers.

Sutton, R. & Wheatley, K. (2003). Teachers' emotions and teaching: a review of the literature and directions for future research. *Educational Psychology Review*, 15 (4), 327–358.

Tsamir, P. & Tirosh, D. (2009). Affect, subject matter knowledge and pedagogical content knowledge: the case of a kindergarten teacher. In J. Maaß & W. Schlöglmann (Eds.), *Beliefs and attitudes in mathematics education: new research results* (pp. 19–32). Rotterdam: Sense Publishers.

Wood, E. (1987). Math anxiety and elementary teachers: What does research tell us? *For the Learning of Mathematics*, 1 (1), 8–13.

Zan, R., Brown, L., Evans, J. & Hannula, M. (2006). Affect in mathematics education: an introduction. *Educational Studies in Mathematics*, 63 (2), 113–121.

Zan, R. & Di Martino, P. (2003). The role of affect in the research on affect: the case of attitude. In M.A. Mariotti (Ed.), *Proceedings of the third conference of the European Society for Research in Mathematics Education*. Bellaria: ERME.

Zembylas, M. (2005). Beyond teacher cognition and teacher beliefs: the value of the ethnography of emotions in teaching. *International Journal of Qualitative Studies in Education*, 18 (4), 465–487.

Notes

1 Qn indicates the question number n.

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