About Relationships in the Affect Domain

Manuela Moscucci[1] and Cecilia Bibbò[2 (*)]

[1,2]University of Siena, Department of Information Engineering and Mathematical Sciences, Italy, manuela.moscucci@unisi.it; bibbo@student.unisi.it

During the last decade the learning and teaching environment has assumed an important role in affect research due to the socio-constructivist account of learning and teaching mathematics. Despite this, the concept of interpersonal relationship, which is an important variable of the environment, has not yet been considered explicitly in affect. The first aim of this paper is to show the importance of studying explicitly this concept in affect research field. The second aim is to underline a first characteristic of the interpersonal relationships. In the light of neuroscience results about mirror neurons, the authors observe that a relationship is characterized not only by the perceptible senses communication, but also by a hidden communication that takes place through mirror neurons sets.

Keywords: Affect, Relationships, Neuroscience, Mirror Neurons, Theoretical Framework.

INTRODUCTION

Until the '90s, the researches about affect in mathematics education have always been rooted in the historical constructs, beliefs, emotions, attitudes (McLeod, 1992) and values (DeBellis & Goldin, 1999). However, during the last decade, many scholars underlined the need of expanding and reorganizing the field, which appeared to be not sufficiently complete (Hannula, 2002; Hannula, Evans, Philippou, & Zan, 2004) and clear about the correlations among the constructs (Hannula, 2011; Hannula et al., 2004; Leder & Grootenboer, 2005). During the same period, other constructs, such as motivation, self-esteem, anxiety, were studied in affect domain. At the same time, some researchers (e.g. Goldin & DeBellis, 2006) switched from the consideration of an individual itself to an individual in his environment, analyzing both beliefs, emotions and attitude of a person, student or teacher, (intro-affect), and the external/interpersonal ones of others belonging to the same environment (inter-affect). In conclusion, during the last decade, affect researchers have highlighted two requirements: the extension of the theoretical framework and the necessity of taking into consideration the environment of growing and learning/teaching of people holding emotions, beliefs, attitudes, values etc. .

TOWARDS *RELATIONSHIPS* STARTING FROM AFFECT LITERATURE

Affect constructs' social component has been studied in literature by many researchers (e.g., De Corte, Op't Eynde, & Verschaffel, 2002; Evans, 2000; Goldin & DeBellis, 1997) who argued that context matters. Already at the beginning of the 90s, some researchers (e.g., Bishop, 1988; Halliday & Hasan, 1989; Henriques, Holloway, Urwin, Venn, & Walkerdine, 1984) were aware of the fact that affect variables are socially constructed in the educational environment. However, only years later, it was claimed

the importance of context in affect research. Op'T Eynde, De Corte, and Verschaffel (e.g., 2006) and Evans, Morgan, and Tsatsaroni (e.g., 2006) analyzed in depth affect in the complex environmental system. This means that thanks to affect literature we realize that social context has a key role in the quality of emotions, beliefs, attitudes, values of people. But now, we would highlight that the characterizing element of an environment are the interpersonal *relationships* that all individuals, of the considered context, establish among them, and with all components of that social environment. The relationships guide the ability of regulating emotions and developing beliefs about ourselves, others and the environment itself. Creating, renovating and modifying beliefs and ability of regulating emotions depends on relationships. The aim of this paper is to underline that in affect there is a hidden key element that has never been explicitly recognized: the interpersonal relationships and relationships, in general (in the following, named only relationships). This 'new' perspective could gain clarification of the notion of belief, emotion and attitude toward mathematics. We believe that relationships could be studied both as what links together affect constructs in a single framework, and what gives new meaning to all constructs. However, as we will see, there is much more. The relevance of relationships comes out not only from the affect literature, but also from the neuroscience one.

ORIGIN OF THE IDEA

The embryonic idea arose a long time ago. In the '80s Moscucci noticed a strange circumstance regarding a primary school teacher, who we will call Rose. Despite not having relevant professional skills, Rose was getting surprising results with her students. Rose's students were generally quite wealthy, but not always of high cultural caliber. Rose, as it used in Italian schools, was the only class teacher of all subjects and taught her students from the age of 6 years old up to age of 11, for 5 consecutive school years, in a small Italian city. Moscucci was astonished by the fact that Rose's students were almost all good students when they went to the high school. This statement does not derive from a statistical survey, but only from Rose's recognized reputation in the city. Moscucci began to look at the case of Rose after a first cycle of Rose's students. Moscucci was struck by the fact that, right at the beginning of the following cycle of teaching, Rose expressed her satisfaction to Moscucci for the skill of her students in the new cycle: children of 6 years only and that Rose had met only a few months before but had already defined as talented and very gifted kids. At the same time Moscucci knew that Rose's students from the first cycle, who were also defined by Rose as exceptional students, were very good in high school. Even Moscucci did not study Rose's case, it remained in her mind, as a researcher in mathematics education, the curiosity to formulate a hypothesis to explain a fact so strange.

Another story. During the last fifteen years Moscucci has conceived and directed many school projects, in Italian schools, aimed at overcoming students' difficulties in mathematics, as, for example, those described in Moscucci, Piccione, Rinaldi, Simoni, and Marchini (2005). In the first part of their realization, the projects were conducted according to a particular educational path, called MBSA, Meta Beliefs Systems

Activity (Moscucci, 2007), which aims to rebuild students' relationship with math. Here it is not important what the whole structure of MBSA is, but only the activity "My story with math" planned in MBSA, when the participants are asked to tell their story with math, with the explicit request to focus their attention above all on emotions experienced during math activities. This activity is widespread in research (e.g., Di Martino & Zan, 2010). So, in those circumstances, Moscucci gathered many significant sentences spoken or written by students with difficulties in mathematics and reflected on them. Beside every sentence, there are questions that arose spontaneously.

> *"Even if the teacher told me I was good at math, she seemed to think the opposite"* (Ada, 15 years old). "In what sense "she seemed"? What did Ada mean?"
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> *"I know that my teacher believes I am not good at math"* (Lisa, 15 years old). "How did Lisa know what her teacher believed?"
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> *"Even if my teacher always smiles at me, I never feel sure and relaxed about what I'm doing"* (Lea, 16 years old). "Why didn't Lea feel sure and relaxed, if her teacher was so nice to her?"
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> *"When I do math homework together with my brother, I feel like he thinks I am slow"* (Sara, 14 years old). "How did Sara realize that her brother thought that she was slow? What did Sara mean when she said "I feel"?"
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> *"When my father is in the kitchen, I am not able to do math homework"* (Giulia, 14 years old). (From the whole interview we knew that usually Giulia did her homework in the kitchen and that Giulia thought of her father believing she was not good at school). "What is it that stopped Giulia?"
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> *"Even if the teacher told me I was good in math she seemed to think the contrary!"* (Amy, 16 years old). "Did Amy really believe that her teacher was thinking the opposite of what she told her?", "Why?"
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> *"When my teacher gave me the report card, I heard her voice in my mind saying 'You will never really understand mathematics*!'" (Deb, 15 years old). We have reached the pinnacle! This girl not only made assumptions about the thoughts of others, but even claimed 'to hear a voice in her mind', her teacher expressing an opinion. Was it just an expression or did she really hear a voice?

We want to point out that the reported sentences were said by students during a school project organized on a vocational school to overcome difficulties in math. So, all the involved students were not good students in math.

NEUROBIOLOGICAL BASIS TO SUPPORTING *RELATIONSHIPS*

The importance of context in learning processes concerns, of course, any discipline, not just math. However, regarding affect, such importance is justified not only as a sector of mathematics education, but it is amplified by the choice of its constructs, emotions, beliefs, attitudes and values. They are just the product of the interaction between the person with his/her environment. Hence, in our opinion, the necessity of

including relationships in affect research studies. Relationships are widely studied and investigated by neuroscience. However, we intend to bring to the attention of affect researchers that is not enough to use the neuroscience results, since it appears to be particularly relevant in this context. Science considers human beings as in continuous interaction with their environment, and neuroscience has already stated the essential role of human interpersonal relationships in the construction of any kind of thought and knowledge. The brain is a 'social organ' of the body, it is exquisitely social, and emotions are its fundamental language. Learning is a relational process that encloses regulation of emotions, that is fundamental in the development of all knowledge. So, what are exactly relationships from a neuroscientific point of view? Neuroscience, at this time, does not give a definition of relationship. However, affect researchers must not retrace the beaten track for decades in search of a definition of beliefs. We may see relationships as a primitive concept and settle for partially characterizing the relationships and study their characteristic elements even if not fully characterizing. We mean, maybe, in the future, other characteristics of relationships might be discovered and studied and we might arrive at a completely satisfactory characterization. The neuroscience result that, in our opinion, is a matter of great interest for affect research, concerns mirror neurons, that are a specific type of neurons. They are involved in a kind of communication unknown until now, at least from a scientific point of view. Mirror neurons, discovered by Gallese and Rizzolatti (University of Parma, I) in 1995, are one of the most important relatively recent discoveries in neuroscience. Mirror neurons "*appear to play a fundamental role in both imitation and action understanding*" (Rizzolatti & Craighero, 2004, p. 169). The activation of mirror neurons is, indeed, able to generate an internal motor representation (potential act) of the act observed, from which learning ability through imitation depends (Rizzolatti & Sinigaglia, 2006). In particular, these neurons should seem to play an important role in imitation learning. They are activated subconsciously, allowing people to trigger processes of imitation and communication without awareness. The human brain has many and many mirror neurons that specialize in carrying out and understanding not just the actions of others but also their intentions, behavior and emotion, through direct feeling (e.g., Gallese, Keysers, & Rizzolatti, 2004). According to researchers, in social relationships, the functions of mirror neurons allow an immediate understanding of what others are doing, without any kind of mediation or interpretive reasoning. Mirror neurons constitute a scientific proof of the existence of a sort of not perceived communication. So, we may claim that communication has visible (or at least sensitive perceived) and conscious components, such as body languages and other sensitive human expressions, but also unconscious and invisible components. We will refer to the last type of communication, with the diction *hidden communication*. The discovery of hidden communication between two people influences the view of the quality of relationships, and it is clear how the consideration of this element of interaction between people intervenes in studies about human relationships. Let's say even more explicitly. Communication through the mirror neurons sets shows that a relationship between two persons is not constituted

only by the set of the interactions between them, perceptible by senses, as, for instance, verbal communication. There is much more. We mean that, at the moment, a relationship between two people is an entity which has to be described fully. In fact, we have said: "*Communication through mirror neurons sets*", but, despite us not being neurobiologists, we believe we can say, as a highly probable hypothesis, that almost certainly mirror neurons are nothing more than a kind of transmitting and receiving antenna. As a matter of fact, knowledge of the functioning of mirror neurons determines a new vision of interpersonal relationships and an absolutely innovative approach to the study of the nature of the relationships. In addition to this, recent evidences suggest that mirror neurons are involved in what is usually called *empathy*, which is the capacity of feeling the same emotions that others feel. Indeed, we can say that this gives a scientific link to something that, up to now, was guessed, imagined, perceived too, but had not a scientific root. "*Empathy, or the ability to share feeling states with other individuals, is an important aspect of affiliative, prosocial behavior in modern-day humans*" (Nelson, 2012, p. 179). Empathy is thus a form of hidden communication. "*At a neurobiological level, empathic responding is thought to reflect activity within distinct neural circuits subserving other social processes such as understanding person-specific experiences (theory of mind) and reflexive activation of observed experiences in others (mirror neurons)*" (ibidem, p. 1). Mirror neurons allow us to feel the mind-state of another person. They automatically and spontaneously pick up information about the intentions and feelings of those around, creating emotional resonance and behavioral imitation as they connect the internal state with those around, even without the participation of a conscious mind. All these means that mirror neurons enable us to connect with each other. They dissolve the wall between one and the others. These results have a significant impact on the study of beliefs and emotions in general. In fact, through mirror neurons, we continuously receive information from all those who take part to our environment. This information, of which we are unaware, greatly contribute to the construction of beliefs or patterns of interpretation of the reality, and therefore the quality of our emotions. Then beliefs, emotions, attitudes and value depend on the relationships that a person has structured over the time, in every context of life, family and school in the first place. Therefore, the consideration of these findings in neuroscience is, in our opinion, a starting point for collaboration between neuroscientists and education researchers, and particularly between neuroscientists and affect researchers. Indeed, there's more from the point of view of affect research. Indeed, all this not only means that there is an interconnection among emotions and beliefs of people, but also that there is a link rooted in neurocerebral mechanisms. All this stresses the importance of the analysis of the relationships of the person, student or teacher of mathematics, in order to understand deeply the quality of his/her emotions, beliefs, attitudes and values. And, all this is not only due to the importance, for affect, of the context from a social constructivist point of view, as it has been highlighted above, but on the basis of new scientific results from related fields of research. A last observation about the case of Rose. When Moscucci first met Rose she was particularly intrigued by some Rose's personal characteristics: her enthusiasm for

her students, her firm belief that all her students were good at learning and very intelligent, and her joy about working with children. The results about mirror neurons allow to hypothesize that Rose transmitted to her pupils her enthusiasm that affected positively their self-esteem and their confidence whose role on learning is well known.

ABOUT *RELATIONSHIPS*

The discovery of mirror neurons states that there are hidden information shared between people, which are absolutely independent from people will. We must take in account that when we work with the relationships we are working with the brain structure. Scientific results about mirror neurons constitute the first step to characterize the concept of relationship also from a neuroscientific point of view. They allow us to talk about *interaction between individuals* not only as communication, in the usual sense of the word. In particular, communication is an exchange of information based on sensory perception. But researches show that the interaction between two individuals are not just communication. A relationship is something much more complex than the set of information of interpersonal communication, even if we look at it in all its forms: verbal, gestural, mimics, tactile, postural, kinesthetic, etc. Then we might refer to these types of communication such as characteristics of the *rapport* between two people, while the *relationship* is characterized by the *hidden communication*, due to mirror neurons, and, perhaps, due to other things yet to be discovered, but, without doubt, due to the hidden communication, that is proved existing. We might say that *sensory communication gives rise to a rapport, while the hidden interaction, or hidden communication, gives rise to a relationship*. The relation between rapport and relationship deserves to be investigated scientifically. For the moment, we can make some considerations based on observation of what happens in the usual social contexts. For example, the experience leads us to believe that there may be a rapport, maybe for many years, between two people between whom there is a weak relationship, while there may be a strong relationship between two people who have just met, and between whom there is a very weak rapport. This may be one reason for distinguishing rapport from relationship. We may say that usually, a relationship and a rapport are co-present, but now we cannot exclude any relation between relationship and rapport. In fact, it is well known that particularly linked people can communicate with each other some moods that are affecting them emotionally, even at a distance. In the literature (e.g. Segal, 2000) there are reports about identical twins, who never met, so without having any rapport, one could perceive fear, for example, experienced by the other. However, although we cannot exclude that there are people between whom there is a relationship, but not a rapport, we must admit that these are really *limit cases*. Hence, when we talk about relationship we mean the set of rapport and hidden communication. To sum up, the study of relationships must take into account their dual nature of communication: explicit and hidden, and the hidden communication will be the component that, henceforth, will contribute more to the advancement of research. The hidden communication that occurs through mirror neurons and on which, at least in part, is based empathy, affect beliefs, emotions,

attitudes, values. The consideration and inquiry of the relationships in their entirety can really help affect researchers to progress about their studies.

RELATIONSHIPS IN THE AFFECT DOMAIN

Affect researches identify beliefs and emotions as essential elements to understand how students build their mathematical knowledge. Learning processes have their origin in the experience, and experience depends on the relationships established between a person and every single other person in his/her environment, and the environment itself. In fact, through relationships, a human being, but surely even animals, begins, early in his/her childhood, to interpret his/her experiences and, in turn, through these experiences of interpretation, s/he builds models of interpretation. These models constitute the basic references to interpret his/her next experiences and, in particular, his/her emotions, along all his/her life. So, emotions are a result of the use of models built through the relationships. In addition, beliefs are shaped through relationships and they are involved in the interpretation of experiences. Then, emotions and beliefs are closely linked and influence each other, because of their nature and their construction which occurs through the relationships. As a consequence, affect constructs have their roots in relationships, and should be seen in absolute dynamicity and synergy. It is really difficult to deal with one of them independently from the others. These are the main aspects which have led us to consider relationships as a key element in the affect domain and, in our opinion, just these arguments are absolutely compelling for considering the relationships in the affect domain. However, we claim that there is another reason, perhaps even stronger, requiring researchers to extend their studies about the relationships and, at the same time, strengthening them. The study of the principles of quantum physics supported again the ideas that have allowed this work to take shape. As we said, many affect researchers have emphasized the importance of the correlation between the constructs. We believe it is useful for the research climate in affect domain, to borrow a principle of quantum physics. Quantum physics shows that the properties of objects manifest themselves as such, only when the objects interact with each other. Then, it is important, in affect, to study not only what are the constructs themselves, but also the relations between them, just to understand their nature. In fact, constructs' nature may emerge completely from the study of the relationships which contributed or contribute to the construction of a certain belief or value, to the manifestation of a certain emotion, to the structuring of a given attitude, or motivation etc.

CONCLUSIONS

The findings of neuroscientists about mirror neurons will certainly have many repercussions in the educational research. The suggestions that we deducted from the research on mirror neurons, convinced that much more come out from research in neuroscience. For example, studies on the contagion of yawning in primates, may allow to make the assumption that the importance of the hidden communication between teachers and students is a possible research hypothesis, and we will make it explicit and deal with in future papers. Studies about the "hidden communication" might really

give great impetus to research in the field of human communication and in all fields in which communication plays an important role, such as education, and, particularly for us, affect. And we absolutely intend to face this issue in the near future. For the development of affect research we support the importance of bringing to light *relationship*s as a real construct and studying it explicitly. The processes of teaching/learning are about people and how people interact. The relationships among people, students and teachers, are involved in these processes. Relationships intervene substantially in these processes and, therefore, must be considered a variable to evaluate the processes of teaching/learning. So far we have studied the relations between emotions, beliefs and attitudes of the student and, to a minor extent, of the teacher. Now affect researchers have to study emotions, beliefs and attitudes of the student closely connected with emotions, beliefs and attitudes of the teacher, namely as a result of the quality of the interpersonal relationship between student and teacher! Which kind of teacher's beliefs, emotions and attitudes could be inhibitory to the student learning process? And which ones could affect positively? How could we act on teacher's inhibitor beliefs, emotions and attitudes? This is just to give some examples of research questions that could really be addressed in affect research, in mathematics education and, more in general, in education. Investigating the profound influence on us of those around us, or what Siegel (e.g., 1999) calls "the neurobiology of we", it will represent another step forward in the development of a comprehensive view of human learning processes, even if these further investigations could not meet our original expectations. At this stage, we may say that the way in which we perceive students regarding the development of their potentialities and abilities in mathematics, could likely affect their success in mathematics and the development of their general potentialities. Within the realm of affect, taking in account relationships means considering not only the belief systems and emotions of students, but also those of their teachers, and not only that. It means to consider these belief systems and emotions as a complex structure, not as static, but dynamic and continuously evolving.

This paper aims just to gain the attention of affect researchers regarding the possible implications that a deeper investigation about relationships could have in the understanding of affective variables in mathematics education.

NOTE

* Cecilia Bibbò worked about the study during the preparation of her Master's Degree Thesis, discussed at the University of Siena, on October 25th 2013.

REFERENCES

Bishop, A.J. (1988). *Mathematics enculturation: A cultural perspective on mathematics education*. Dordrecht, The Netherlands: Kluwer Academic Press

DeBellis, V.A., & Goldin, G.A. (1997). The affective domain in mathematical problem solving. In E. Pehkonen (Ed.), *Proceedings of PME 21* (Lahti), 2, 209-216

DeBellis, V.A., & Goldin, G.A. (2006). Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies in Mathematics, 63,* 131-147

De Corte, E., Op't Eynde, P., & Verschaffel, L. (2002). "Knowing what to believe": The relevance of students' mathematical beliefs for mathematics education. In B.K. Hofer & P.R. Pintrich (Eds.), *Personal Epistemology: The Phychology of Beliefs About Knowledge and knowing*, Lawrence Erlbaum Associates, Mahwah, NJ, 297-320

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

Evans, J. (2000). *Adults' Mathematical Thinking and Emotions: A Study of Numerate Practices*. London: Routledge Falmer

Evans, J., Morgan, C., & Tsatsaroni, A. (2006). Discursive Positioning and Emotion in School Mathematics Practices. *Educational Studies in Mathematics*, Special Issue on Cognition and Affect in Mathematics Classrooms, 63(2), 209-226

Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences, 8,* 396-403

Halliday, M.A.K., & Hasan, R. (1989). Language, context, and text: Aspects of Language in a social-semiotic perspective. Geelong, Australia: Deakin University

Hannula, M.S. (2002). Attitude towards mathematics: emotions, expectations and values, *Educational Studies in Mathematics, 49 (1),* 25-46

Hannula, M.S. (2011). The structure and dynamics of affect in mathematical thinking and learning. In M. Pytlak, E. Swoboda, & T. Rowland (Eds.), *Proceedings of the seventh Congress of the European Society for Research in Mathematics Education*. University of Rzesów, Poland, 34-60

Hannula, M.S., Evans, J., Philippou, G., & Zan, R. (2004). Affect in Mathematics Education Exploring Theoretical Framework. *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education I*, 107-136

Henriques, J., Holloway, W., Urwin, C., Venn, C., & Walkerdine, V. (1984). *Changing the Subject: psychology, social regulation and subjectivity*. London: Methuen

Leder, G., & Grootenboer, P. (2005). Affect and Mathematics Education. *Mathematics Education Research Journal, 17 (2),* 1-8

McLeod, D.B. (1989). Beliefs, attitudes, and emotions: new view of affect in mathematics education. In D.B. McLeod & V.M. Adams (Eds.), *Affect and Mathematical Problem Solving: A New Perspective* (pp. 245-258). New York: Springer-Verlag

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.575-598). New York: Macmillan

Moscucci, M., Piccione, M., Rinaldi, M.G., Simoni, S., & Marchini, C. (2005). Mathematical discomfort and school drop-out in Italy. *Proceedings of CERME4*, 245-255

Moscucci, M. (2007). About mathematical belief systems awareness. *Proceedings of CERME5*, 298-308

Nelson, E.E. (2012). The Neurobiological Basis of Empathy and Its Development in the Context of Our Evolutionary Heritage. In D. Narvaez, J. Panksepp, A.N. Schore, & T.R. Gleason (Eds.), *Evolution, Early Experience and Human Development: From Research to Practice and Policy*. New York: Oxford University Press

Op't Eynde, P., De Corte, E., & Verschaffel, L. (2006). Accepting Emotional Complexity: a Socio-Constructivist perspective on the role of emotions in the mathematics classroom. *Educational Studies in Mathematics, 63*, 193–207

Segal, L.N. (2000). *Entwined Lives: Entwined Lives: Twins and What They Tell Us About Human Behavior*. New York: Plume, 2000

Siegel, D.J. (1999). Relationships and the developing mind. *Childcare Information Exchange*, 48-51

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annu Rev Neurosci*., *27*, 169-192

Rizzolatti, G., & Sinigaglia, C. (2006). *So quel che fai* [I know what you are doing]. Raffaello Cortina Editore

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