Introduction to the work of TWG 8: Affect and the teaching and learning of mathematics

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Stanislaw Schukajlow[1] (Chair), Inés M[a] Gómez-Chacón[2], Çiğdem Haser[3], Peter Liljedahl[4], Karen Skilling[5] and Hanna Viitala[6]

[1]University of Münster, Germany; schukajlow@uni-muenster.de

[2]Universidad Complutense de Madrid, Spain; igomezchacon@mat.ucm.es

[3]University of Turku, Finland; cigdem.haser@utu.fi

[4]Simon Fraser University, Canada; liljedahl@sfu.ca

[5]King's College London, School of Education, UK; karen.skilling@kcl.ac.uk

[6]Luleå University of Technology, Sweden; hanna.viitala.edu@gmail.com

Introduction

In this chapter, we would like to introduce discussions about the affective constructs and their relation to teaching and learning of mathematics. Before the conference, we agreed to change the title of TWG from "Affect and mathematical thinking" to "Affect and teaching and learning of mathematics". The new title of the group better reflects the broad scope of research that we welcome in our group. All types of affective constructs that emerges in relation to both *learning* and *teaching* of mathematics could be represented and discussed in the working group during the conference.

The number of submissions and participants confirmed the interest of mathematics education researchers in affect. In total 26 papers and 3 posters were submitted to our group, with 24 papers and 2 posters were accepted for presentation, and 23 papers and 2 posters accepted for publication in these conference proceedings. Our group included presentations from Canada, Israel and different European countries. Participation of researchers from 15 countries (including 13 newcomers) reflected the spirit of inclusion that is traditional for this group that has been discussing affect in mathematics education in recent years.

We started our work with an introductory, ice-breaking activity and a reflection of the work done in previous conferences. This year we decided to considerably increase the time for discussions of each paper and structured the paper and poster presentations and discussions in a new way. After a short presentation (7 min) and clarifying questions (3 min) of papers that we scheduled within each session, authors of presentations discussed their research (30 – 40 min) with other group members in small groups. Participants could decide which paper or poster they would like to join for discussion. We assigned contributions to the sessions in groupings related to: affect; emotions; identity; beliefs; and motivation or attitudes/engagement. At the end of each session, we shared our thoughts about these topics with the whole group. In the final session, we discussed new perspectives on affect and related constructs that emerged during our work.

Reflection on prior research in affect

Peter Liljedahl presented a comprehensive overview of the work that has been done during the past CERME conferences. Çiğdem Haser and Stanislaw Schukajlow picked up and elaborated on this overview during the presentation of the report about the work of the TWG8. The starting point for systematic research on affect in mathematics education is usually a review paper by McLeod (1992). In his seminal work, the author introduced an influential taxonomy of affect. According to this taxonomy, affective constructs can be assigned to different points on the line that ranges between beliefs through attitudes to emotions. Beliefs were proposed to be most stable, less affective and most cognitive, whereas emotions were noted as less stable, most affective and less cognitive.

In the last decades, researchers underlined repeatedly that the complexity of affect requires elaborating the taxonomy proposed by McLeod. For example, Hannula (2012) analyzed research in mathematics education and suggested a need to distinguish between three dimensions as common foundations for a theoretical framework. These included: cognitive, motivational and affective dimensions; unstable states and stable traits; and social, psychological or physiological nature of affect.

Recently, object of the affect (affect about life, learning, problem solving or strategy use), subject (teacher or students) or valence (positive or negative) were suggested to be important for research on affect (Schukajlow, Rakoczy, & Pekrun, 2017). Further, the theoretical approach (acquisitionist or participationist) play an important role. Affective constructs that were explicitly anchored in the taxonomy by McLeod were investigated and new dimensions were proposed. For example, teacher beliefs about the nature of mathematics and their relation to learning can be assigned to beliefs about nature of mathematics, beliefs about mathematics teaching and beliefs about mathematics learning (Beswick, 2012). Teacher beliefs build a so-called belief system that start its development in the school years, changes in university years and is shaped based on the practical experience encountered by in-service teachers.

An important point raised in prior discussions related to the definitions used for characterization of affective constructs. As affective constructs are seen as complex phenomena the definitions of particular constructs often overlap with other affective constructs and are criticized as being circular. For example, emotions are defined as phenomena that included cognitive, affective, motivational, physiological and expressive parts. Affect and motivation are used in this definition thus for characterization and grounding of emotions.

Finally, reciprocal relationships between affective constructs and students' achievement is acknowledged and are crucial for understanding the role of the affect in teaching and learning. Most of the studies in the TWG8 targeted affect and implied problems with affective constructs as a reason for difficulties in teaching and learning. However, another perspective is also valuable, whereby students' or teachers' affective problems while learning or teaching might result from problematic achievements in the past.

Contributions in the TWG8

In this section, we would like to present the papers that we included in these proceeding. Gómez-Chacón and Barbero investigated students' perception of backwards strategy in problem solving. Forbes et al. analyzed students' mindsets and its relation to self-confidence in programming. A low achiever's mathematical thinking was analyzed by Viitala in a case study.

Alcantara et al. explored students' failure experience and identified emotions hopeless, shame, frustration and fear. Relation between anxiety about generating drawings and students' gender, strategical and cognitive factors was analyzed by Schukajlow et al. Lake reported on the study that investigated how data about emotional state can be used during reflection on teachers practice.

An instrument for measurement of students' identity was developed and applied by OReilly at al. Narratives on student identity within a social-cultural environment were explored by Ben-Dor and Heyd-Metzuyanim. Howard et al. applied thematic topic analysis for research on students' identity and its relation to mathematics in higher education.

Figueiredo and Guimarães carried out a study on learning styles and their relation to performance. Van Hoeve et al. investigated students' mindset. An analysis of questionnaires for students' self-concept of mathematics in school and university was presented in the contribution by Rach et al. Westerhout et al. analyzed the effect of the project about game programming. The development and evaluation of the general and domain-specific scales for self-concept and interest were analyzed by Sproesser et al.

First-person vicarious experiences was found to be crucial for the change of beliefs by Rouleau et al. Pantziara et al. presented a study on validity of the scale about teachers' epistemic beliefs. Wiik and Vos reported on the study about reasons of choosing advanced mathematics courses in secondary school. Using metaphors for exploring pre-service teachers' beliefs was analyzed by Haser. Liljedahl presented an analysis of master and doctoral students' beliefs about research (Liljedahl, 2018).

Engagement in students' interactive storytelling and its impact on attitudes were explored in the contribution by Pierry et al. Novotna analyzed private supplementary tutoring and its relation to students' attitudes. Different levels of engagement (high and low) were distinguished in students with the same achievement level in the study by Skilling. Haataja et al. demonstrated that gazes at teachers' and at students' faces differed in small- and whole-group instructions. Kourty analyzed cognitive, behavioral and affective aspects of engagement in inquiry-based learning.

In posters, Hansen discussed collaborative processes while solving problems and Barton introduced a study on self-made tutorials.

Evolution of the TWG

The overall quality of the submitted contributions increased and this resulted in acceptance of nearly all papers and posters for presentation at the conference. Contributions investigated affective measures of different subjects: primary and secondary school students, pre- and in-service teachers and doctoral students. Most of the researchers applied qualitative analysis and performed case studies, in order to answer their research questions. Thus, the distribution of submissions followed

the general trend toward the dominating role of qualitative studies in research on affect (Schukajlow et al., 2017). One reason for this trend might be the efforts of researchers to capture the whole complexity of the affective phenomena and analyze it in relation to cognitive and strategical behavior. In our discussions about methodological issues, we pointed out that even researchers who applied qualitative methods should be aware that they can get only one "slice" of phenomena, even though it is usually more rich than in quantitative studies. On the other hand, researchers who applied quantitative analysis often pretend to produce objective and valid results. In this type of analysis, limitations concerning operationalization and generalizing should be carefully addressed. The choice of research method should be derived not by general preferences of what is the "right" or "wrong" type of analysis, but by research questions that the researcher is interested in.

A new trend in the group was the appearance of several papers on identity. In their studies, researchers reported on how they assess identity and tried to understand this complex phenomenon. Assessment and theoretical background seem to be closely related to each other in research on identity. New theoretical approaches, such as theory of mindsets and theory of identity appeared in the papers this year. Further, we had again contributions that referred to psychological theories such as control-value theory of achievements emotions, theory of self-concept and other theories. Most of the studies investigated students affective state reflecting researchers' interest in what is going on during learning. The new object of affective construct, emotions and perceptions regarding strategies used during problem solving, appeared for the first time in our group. Another trend is an investigation of the affect in learning environments that included programming as part of the treatment.

During our general discussion, Liljedahl summarized by using the scheme for assessment categories in research on affect (Table 1). Studies can address individuals or social variables (subject) within social or individual context. For example, if researchers investigated beliefs of individuals during group work, the subject is the individual and context is social.

		Subject	
		social	individual
Context	social		
	individual		

Table 1: Assessment categories in research on affect

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