Chapter 1
Fresh Perspectives on Motivation, Engagement, and Identity: An Introduction

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1.1 Setting the Scene

Well over a century has passed since the founding, in Rome in 1908, of the International Commission on Mathematical Instruction [ICMI]. Over time, the interest among mathematicians in school mathematics intensified: "as the mission of general education expanded (more advanced knowledge, for more people), the needs and complexity of mathematics education grew as well, leading to the development in due course of corresponding communities of both practicing professionals and scholars" (ICMI, no date, para 5).

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A new phase began some six decades after that meeting in Rome. In 1969 mathematicians and mathematics educators convened officially, in Lyons, at the first International Congress on Mathematical Education [ICME] conference. Further ICME conferences followed: next in the leap year of 1972, then every four years, and most recently in 2016 in Hamburg where ICME-13 was held.

1.2 Genesis of the Book

Almost 3500 participants from 105 countries took part in the ICME-13 conference. "The heart of the congress", wrote Kaiser (2017, p. 3) "consisted of 54 Topic Study Groups, devoted to major themes of mathematics education, in which 745 presentations were given". Among these was the Topic Study Group 28 on "Affect, beliefs and identity in mathematics education" which, in turn, spawned the contents of this volume.

> Topic Study Group 28 [TSG28] was aimed at addressing all areas of affect, including attitude, anxiety, beliefs, meaning, self-concept, emotion, interest, motivation, needs, goals, identity, norms, values. The different approaches to study affect included psychological, social, and philosophical research perspectives. Moreover, the call for papers explicitly questioned the issue of the mutual relationship between affective constructs and their connection to cognition and other constructs studied in mathematics education, as well as the description of programs for promoting aspects of affect.
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> The activity of the working group was aimed at:
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> - Presenting an overview of the state of the art in the research field of affect in mathematics education, both at the students' and the teachers' (pre-service or in-service) level.
> - To identify new trends and developments in research and practice in these areas.
> - To engage participants in a critical reflection of this research field and generate discussion of an agenda for future research on affect in mathematics education. (Hannula, Morselli, Erktin, Vollstedt, & Zhang, 2017, p. 507)

Two key measures were adopted to cope with the large number of papers submitted to TSG28, and yet ensure that each participant was allocated an adequate time for the presentation and discussion of his or her report. These were to use a process of peer review for the material submitted and to accept the need to schedule parallel sessions in the times allocated for the topic group. An overview of the various TSG28 presentations—their content and mode of delivery—can be found in Hannula et al. (2017). Collectively, the body of material presented, the lively discussions that ensued, and the thirst for continued work in the field of affect and mathematics education underpinned the development of the present volume.

Post ICME-13 preparations for the book largely followed an expected course. In the first instance the team needed to shepherd the new volume from conception to completion was finalized. This was followed by a call for an expression of interest to those involved in TSG28 and who might wish to modify and enlarge their initial contribution for inclusion in a follow-up volume. By the closing date for this call, 33

reworked papers had been submitted. A further peer-reviewing process was put in place, with each of the reworked papers reviewed by at least one external reviewer and one member of the editorial team. Just under half of the work submitted (15 chapters) was judged to be suitable for inclusion in the book. These contributions were ultimately clustered as follows: a stand-alone overview chapter, followed by three sections with the provisionally titled headings of interest, motivation, and values; engagement and flow; and identity. To enrich and broaden the contents of the book even further, the assistance of three established mathematics educators, well versed in the field of affective research, was sought. Each was asked to write a succinct commentary and critique on one of the three clusters. In this way the final product comprised 20 chapters: 15 written by participants in TSG28, three commentaries, as well as an introduction and concluding chapter written by the editorial team.

1.3 The Affective Domain and Mathematics Education

Mathematics-related affect—or affect in general—is a research area with a variety of theoretical approaches so broad that it borders on being harmful (see, e.g. Hannula, 2012 and the chapter by Gilah Leder in this volume). Hannula (2012) has suggested three dimensions to categorize theories related to affect. The first dimension identifies three different types of affect: cognitive (e.g. beliefs), motivational (e.g. values), and emotional (e.g., feelings). The second dimension distinguishes between theories that focus on the relatively stable aspects of affect (i.e. traits) from the theories that focus on the dynamically changing aspects of affect (i.e. states). The third dimension identifies three different traditions for theorizing affect: physiological theories, psychological theories, and social theories. These three dimensions informed the categorisation of chapters in this book. Interest, motivation, and values all relate to the motivation aspect of mathematics-related affect. Flow and engagement includes three papers that focus on the dynamically changing affective states. The third section of the book includes three chapters explicitly focusing on identity, a social theory. It also includes one chapter with a focus on teacher professional beliefs, which we, the editors, considered to be so closely related to the two papers on teacher identity that they should be grouped together.

1.4 About the Book

As mentioned above, the book comprises three main sections which cover different yet overlapping themes. The international mix of the contributing authors (and of the reviewers of the work) is noteworthy, and undoubtedly contributes to a diversity of perspectives captured, and ensures that relevant research beyond that published in English is more likely to be referenced.

1.4.1 Overview

To provide a common context for those who attended TSG28, Gilah Leder had been asked to present an overview of the state of the art of research on affect and mathematics education, with a special emphasis on gender issues. The opening chapter, *Mathematics-related beliefs and affect*, still reflects this request. The use and abuse of terms linked to the affective domain and the evolution of theoretically driven attempts at more definitional precision and consistency are outlined. Historical and contemporary approaches enlisted to probe the interaction between affect and mathematics learning are delineated. Snapshots of recent research are used to sketch currently accepted findings and highlight potentially promising new avenues for further research. Where deemed relevant and appropriate the impact on research in the affective domain of work conducted by those concerned with gender issues is also foregrounded.

1.4.2 Interest, Motivation, and Values

Kay Achmetli and Stanislaw Schukajlow report on their project MultiMa. In their chapter *Multiple solutions, the experience of competence, and interest* they show how students' learning is affected when they are asked to construct multiple solutions of real-world problems using different mathematical procedures. Their theoretical background is threefold and gives a concise summary of the relevant research on interest, experience of competence, as well as multiple solutions, and real-world problems. In their experimental intervention study, they investigated 307 ninth graders from twelve middle track classes. The study consists of two sessions, each of 90 min and framed by pre- and posttest on interest. The students' experience of competence was assessed through a short survey in session two. Three treatment conditions were implemented: In the multiple solution group, students were asked to produce two solutions for the real-world problem using two different mathematical procedures. The other two groups were asked to apply one specific procedure to solve the problem. Achmetli and Schukajlow developed a complex path model to hypothesise the influence of the development of one versus multiple solutions on the experience of competence and interest at post test, as well as the interaction of experience of competence and interest. "The results indicate that constructing multiple solutions has a positive influence on students' experience of competence but no effect on their interest in mathematics."

Tracy E. Dobie focuses on the students in her chapter: *A sociocultural examination of utility value in mathematics: The role of interdependence in middle school students' perceptions of usefulness.* She considers the relationship between students' personal values, which she understands as one facet of identity, and the perception of usefulness of mathematics. The conceptual framework draws on Eccles and Wigfield's (2002) expectancy-value model with a special focus on utility value. In addition, a

sociocultural perspective is taken, bearing in mind that the Self is in relation to others and that mathematical understanding is also developed in out-of-school activities and families/communities. The participants in Dobie's study are 84 students from four seventh-grade classes with diverse ethnical backgrounds, feeling most comfortable speaking English and Spanish. Nearly 70% of the students were from low-income families. A special strength of Dobie's chapter is the triangulation of different data: student surveys to collect data on students' values and views of usefulness of mathematics, ethnographic classroom observations, and student interviews. Results show that the usefulness of the mathematics to be learnt is greatly important for students. In addition, "strong interdependent values related to both helping their families and collaborating with others" are shown. Some students even relate their independent values and the usefulness of mathematics.

In their chapter entitled *A longitudinal study of mathematics and science motivation patterns for STEM-intending high schoolers in the US*, James Middleton, Daniel Mangu, and Andrew Lee address the effect of motivational factors on students' intentions towards careers in STEM. The study draws on previous research on STEM education and on the effect of affective factors such as interest and self efficacy on STEM orientation. One special aspect of the reported study is the longitudinal nature, namely the specific focus on the changes of intentions throughout high school years. The study draws on data from the *High School Longitudinal Study* of 2009, which surveyed over 24,000 US students in ninth grade and again in eleventh grade. Motivational factors include identity, interest, utility, self-efficacy, and effort. Data show that occupational intentions change significantly between ninth and eleventh grades. The quantitative analysis addresses links between motivation factors and STEM career intention. Those who leave STEM orientation report a general decrease in interest, identity, self-efficacy, and utility. Conversely, those who initially had not chosen a STEM orientation and after two years change their mind, report a general increase in the same motivational variables. Moreover, the relationship between STEM intention and motivation is proved to be highly time-sensitive. As the authors point out, "students' motivations are highly located in the moment. Their experiences in mathematics and science in one year may not be related strongly to their experiences in another year, and their motivations, being tied to the experiences at hand, seem to be highly unstable". In their conclusion the authors indicate further research that is needed and advocate for a special attention in curriculum development, so as to maintain STEM subjects attractive for students.

Emmanuel Bofah and Markku S. Hannula, in their chapter *Perceived social support network and achievement: Mediation by motivational beliefs and moderation by gender*, study the link between perceived social support (as received from teachers and parents) and achievement. In particular, they study the possible mediating role played by extrinsic and intrinsic motivation and the possible moderating effect of gender. The relationship between achievement, motivational beliefs, and gender is conceptualized through the expectancy-value theory (Eccles (Parsons) et al., 1983). The authors perform a quantitative analysis, drawing on TIMSS 2011 data related to five African countries (Ghana, Botswana, South Africa, Morocco, and Tunisia). The focus on African countries is one special aspect of the study that can shed light

on the issue of achievement in African countries, as well as test the generalizability of results previously obtained in other contexts. The study shows that "the association between perceived social support and achievement is accounted for entirely or partly by how the students value and like mathematics". In other words, teacher (and parent) support is beneficial when a student likes and values mathematics. The study data also show that gender has a moderating role on the effect of motivation, and that such a role varies across countries.

Maike Vollstedt and Christoph Duchhardt explore the concept of *personal meaning,* defined as "personal relevance of an object or action, when dealing with mathematics" (Vollstedt, 2011) in their chapter *Assessment and structure of secondary students' personal meaning related to mathematics*. The authors provide a theoretical background concerning the concept of *meaning* in mathematics education and discuss, from a theoretical point of view, the link between *personal meaning* and other constructs such as interest, motivation, values, and goals. A model for personal meaning, made up of 17 types, developed by Vollstedt in a former qualitative study (Vollstedt, 2011), is presented. Afterwards, the chapter reports a quantitative study aimed at assessing the 17 types of personal meaning and, thus, validating the theoretical model, by means of a questionnaire administered to 193 German students (age: 15–16). Cluster and correlation analyses generally support the theoretical concept of personal meaning. Exploratory factor analyses also suggest two meta-factors structuring the different personal meanings into those showing an orientation to mathematics and to social inclusion.

In her chapter, *Middle school boys' and girls' own expressions of aspirations for their mathematics learning*, Karina Wilkie draws on a large and diverse sample of more than 3500 middle school students to explore their aims and reasons for learning mathematics. The students came from 31 government and independent schools which varied in size and socioeconomic status and were spread across three states in Australia. A synopsis of relevant research precedes a description of the study, the instrument administered, and the analysis of the data gathers. This sketch offers a useful context and justification for the study carried out and reported, particularly for those less familiar with the broad research literature on affect and mathematics learning. The large sample size adds to the strength of the analysis of the data by gender. The use of "an open-ended response format to investigate the different facets of students' aspirations as expressed by the students themselves, without any a priori motivation constructs enabled [an] interpretive content analysis of their spontaneous responses", places students' voices at centre-stage and is certainly a further distinctive feature of the work.

Valorie Zonnefeld, in her chapter *Implications of training in incremental theories of intelligence for undergraduate statistics students*, studies the effect of a training course on growth mind-set (Dweck, 2006) on students' mastery of statistics and attitude towards statistics. The study involves 121 US students enrolled in introductory statistics courses. All students completed both a pre-test and post-test which examined attitudes towards statistics and mastery of statistics. Students in the treatment group received training in incremental theories of intelligence throughout the semester. The quantitative study examines the effect of such a training, with a focus on

gender differences. Females in the treatment group demonstrate statistically significant greater growth in comparison to males regarding their attitudes towards statistics and mastery of statistics. The final part of the chapter contains recommendations for practice (how to exploit the results of the study so as to increase the representation and achievement of females in STEM), as well as suggestions for further research on the topic.

Wee Tiong Seah compared and contrasted these seven chapters in his contribution *Extending the research discourse: From interests and beliefs to values*. Research in the 'values in mathematics' domain served as an important unifying theme in his analysis of these chapters. This affective lens not only added a perspective not covered explicitly elsewhere in this volume but also enabled him to conclude that: "this section has pushed the boundaries of academic knowledge in the field a great deal".

1.4.3 Engagement and Flow

Marina De Simone examined a teacher's moment-to-moment decisions in her chapter, *Intertwinement of rationality and emotions in the mathematics teaching: A case study.* In her framework, she extended the Habermasian rationality with an affective dimension. The case study focuses on one Italian mathematics teacher, whose classroom behaviour was video recorded over five lessons. The data were analysed in detail with attention to not only verbal utterances, but also to gestures, facial expressions, and tone of voice, which were considered as potential emotional indicators. Moreover, the aim of the research was "to go beyond the Cartesian dualism between the *res extensa* and the *res cogitans* towards a holistic view between body and mind." The analysis focuses on identifying the epistemic, the teleological, and the communicative emotionalities, and through these, Marina De Simone is able to explain why the teacher "spoke in a particular manner within the classroom when she was trying to help her students understand". Specifically, while the teacher actions could be understood within the rationality framework, the affect component was necessary to explain the underlying reasons for these actions.

Deena Kahlil, Elizabeth Lake, and Ayanna Johnson, in their chapter *Teachers' classroom engagement structures: A comparative study of a novice US and an experienced UK mathematics teacher*, study the affective states of a novice teacher and an experienced one. The theoretical framework they employed refers to the concept of *engagement structure* (Goldin, Epstein, Schorr, & Warner, 2011), initially developed for studying students' affect; the authors use the concept, in an original way, to better understand teachers' affective states. For their study the authors draw on material from a wider data collection carried out in the US and UK. In the chapter, two case studies are presented and discussed. The analysis suggests that the theory of *engagement structures* may link teachers' prior affective states as learners to their current affective state as teachers. Moreover, teacher education may use the idea of

engagement structure to help teachers to connect their affective states to those of their students.

Drawing on Mihaly Csíkszentmihályi's flow theory, Ana Belén Montoro Medina, and Francisco Gil Cuadra focus in their chapter, *Exploring flow in pre-service primary teachers doing measurement tasks,* on the characteristics of mathematical tasks that evidently stimulate the occurrence of flow. Using a multi-phase approach, data were gathered from 230 pre-service primary teachers enrolled in a course about teaching and learning measurement at a Spanish university. In their study, the authors searched for evidence of flow while bearing in mind its constituent features: "a positive and gratifying state of consciousness … a situation of high concentration, involvement, enjoyment, absorption in the task, unselfconsciousness, control, and clear-cut feedback on the course of activity" (Hektner, Schmidt, & Csíkszentmihályi, 2007, p. 26). As in other chapters, an overview of relevant literature appropriately precedes the description of the study, the approach adopted, and the analysis and interpretation of the quantitative and qualitative data gathered. Through intensive scrutiny of participants' responses and behaviours, including material captured on video and gathered while participants solved measurement tasks, factors that appeared to influence flow are identified. Among these is the composition for group work. "We believe", Montoro and Gil wrote, "that when task complexity levels increase rapidly, using heterogeneous groups hinders the flow experience in students with lower mathematical skills, as they lack time to reflect on the tasks or to draw their own conclusions".

Peter Liljedahl then provides a rich and reflective commentary *Accounting-of and accounting-for the engagement of teachers and teaching*. By drawing on a diverse yet overlapping body of literature under headings such as 'engagement structure', 'studenting', 'flow', and 'modes of engagement', he set the scene for a more focussed discussion on the 'engagement of teachers and teaching' and ultimately on the work included in the chapters in this section and their location in the broader field, both within and beyond mathematics education. "Although", he writes "each of these chapters is, ostensibly, about understanding engagement, each of the results also makes a contribution to our understanding of how to create engagement".

1.4.4 Identity

In their chapter, *The interplay of rationality and identity in a mathematical group work*, Laura Branchetti and Francesca Morselli adopt a social-cultural perspective. They combined the lenses of rationality and identity as their research framework to analyze a series of episodes issued from different teaching experiments, gathered in grade four and in grade six respectively. Through the use of networked analysis, the authors show that both social skills and disciplinary issues influence the students' ability to participate in group work in a quite complex way. In particular, only a good mathematical identity, which means that the student feels he/she is good in mathematics, may lead the students to participate in the group work moving to an epistemic level and thus to develop relevant social skills related to mathematics. That

the teacher plays a significant role in the construction of students' identities in group works is also confirmed. The interaction between teacher and students involves not only the mathematizing but also the identifying process.

Ralf Erens and Andreas Eichler, in their chapter *Belief changes in the transition from university studies to school practice*, address prospective and trainee teachers' beliefs, with a special focus on belief change that occurs when school practice starts. The chapter contains an overview on mathematical beliefs as well as on teacher change. Moreover, since the study focuses on beliefs concerning the teaching of calculus, part of the theoretical background presented in the chapter is devoted to relevant studies on the teaching of calculus. The qualitative study involves 20 German prospective and trainee teachers. Results confirm that central beliefs remain quite stable during the training period, while peripheral beliefs change slightly. Possible causes for change are identified in the *authority* and *reflection* factors.

In his contribution *The struggle for recognition and the professional identities of mathematics teachers*, Clyde Felix explored South African mathematics teachers' professional identities through their struggles for recognitions in the context in which they are situated. Through a narrative approach, these teachers' stories of their struggles for recognition were collected to shape their professional identities. During the semi-structured interviews, three mathematics teachers were asked to reflect on different stages in their professional teaching careers. These include the high points, low (nadir) points, and turning points. The author combines Honneth's (1995) levels of recognition, Kelchtermans (1993) components of the retrospective dimension of a professional self, and Huttunen and Heikkinen's (2004) circles of recognition to analyse teachers' narrative stories. Results show that these teachers' stories have much in common. Their struggles for recognition are at the level of self-esteem, which is for recognition of their worth as mathematics teachers. The teachers have also developed an ability to cope by counterbalancing the negative effects of a lack of recognition with the positive effects of recognition sourced from experiences elsewhere.

Andreas Karaolis and George Philippou, in their chapter *Teachers' professional identity*, reported the development of a scale to measure teachers' professional identity. Factor analysis was used to examine the responses of 315 primary teachers on a trial scale. This led to the final scale which comprised 48 items, clustered in seven factors: self-efficacy, constructive perceptions, intrinsic motivation, extrinsic motivation, traditional perceptions, future perspective, and professional commitment respectively. Teachers' individual characteristics were found to relate to some scale factors. For instance, as the teacher's service time increased, their internal motives tended to decline. Teachers with advanced graduate studies held more constructivist perceptions and simultaneously less traditional perceptions. Hierarchical cluster analysis led to three groups of teachers with different identity profiles. Apart from the quantitative data analyses, 20 primary teachers from different groups were selected for semi-structured interviews in order to deeper examine how teachers conceptualize themselves at work and locate possible differences among teachers with different professional identities. Results show that the differences concerning the teachers' professional identity factors are more pronounced among teachers with

different professional profiles than with teachers belonging to the same group. The authors suggest that more attention should be paid to teachers' motivation during teacher education.

This section ends with Einat Heyd-Metzuyanim's analysis and reflections on the four papers in her chapter *Identity at the crossroads, collision or conciliation? A commentary.* As she points out, the "wide variability of empirical domains, disciplines and methodologies, and especially the fact that these do not necessarily form into neat packages, signals that identity in mathematics education is a field at the crossroads of various disciplinary approaches". She then elaborates all four chapters using a framework that "conceptualizes identity construction as a discursive or communicational activity", making two observations. First, there seems to be a gap between identity and mathematics, and also these chapters "found it difficult to connect between the 'self' and the mathematics with which this 'self' engages". Second, she discusses how in these chapters as in identity research in general the informant's and the researcher's narratives often collapse, prioritizing the researcher's voice and hiding alternative interpretations. Finally, she ends with a conclusion that while there is great variety in the approaches of these four chapters, "each of the approaches is valuable and therefore, none of them should be dismissed. How they should talk to each other, however, remains an open question."

1.4.5 Conclusions

Finally, the chapter *Fresh perspectives on motivation, engagement, and identity: A conclusion*, reflects the contents of the book, especially in relation to the issue of the mutual relationship between affective constructs and their connection to other constructs, as well as the description of programs for promoting aspects of affect, which were specified in the call for papers. The chapters represent a wide variety of theoretical and methodological approaches from beliefs to flow and from narrative analysis to structural equation modelling. A word count analysis of affect terms indicates a clear emphasis on motivational concepts in the book. Moreover, there are only a few chapters looking at the dynamics of the affective states while most chapters look at the relatively stable states. Embodied and social approaches are present, but less prominently than theorizing that focuses on the individual psychological constructs.

Research in mathematics-related affect continues to be rich and diverse. In this book there are both chapters that build on extensive research in the field as well as interesting new openings to the directions less explored in mathematics education to this date.

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