Topic Study Group 4

Mathematics Education for Students with Special Needs

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1. Aims of the TSG

In TSG-4, we focused on a variety of theoretical and practical topics related to supporting the mathematical development of students with special needs as well as teachers' support of students. Throughout the presentations we actively searched for connections both in regards of methodology, theory and the possible impact of the presented research. We aimed to explore five related themes: 1) how do we define "special needs", 2) what are the benefits of differing instructional contexts (e.g., 1-1 teaching as opposed to inclusive settings), 3) how do we reconcile the variety of frameworks that originate from two different fields, special education and mathematics education, 4) what are the characteristics of effective professional development programs that aim to support teachers of students with special needs, and 5) what are the pros and cons of different research methodologies within our context (e.g., single case design and classroom teaching experiments)? We encouraged submissions that offered theoretical and/or empirical contributions and sought to include research from a variety of cultural contexts to enhance our discussions.

1.1. Submissions

We received 35 submissions from 21 countries (South America: 3; North America: 8; Asia: 3; Europe: 17; Africa: 2; Australia: 1; Eurasia: 1), thus reaching our goal of diverse cultural representation. Of those 35 submissions, twenty-seven were accepted as paper presentations, seven as posters, and 1 was rejected.

1.2. Sessions

There were so many high-quality submissions, the ICMI organizing committee granted our TSG one more time slot for presentations. In our first 90-minute session, the TSG Chair, Michelle Stephan, introduced the rest of the Team and described the format of the sessions. Generally, all four-time sessions led with a 25 minutes *long* oral presentation and discussion and two to three *short* oral presentations with a 10-minute collective discussion. Throughout the four days, we attempted to facilitate participant dialogue in order to collective identify emerging research themes, potential interdisciplinary approaches and

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future research opportunities. Discussion time was critical for fostering participant networking as well as countering “virtual conference” fatigue. At the end of our last session, we built in 50 minutes for whole group reflection, discussion and suggestions for needed research trajectories.

1.3. Paper Topics

Of the 27 accepted papers, only 18 papers were able to be presented during the online conference. A list of these papers and authors are included in order of presentation and are organized in Tab. 1.

Tab. 1. List of papers presented

Paper and author(s)
[1] Mathematics learning difficulties? The impact of a constructivist oriented approach to intervention for young learners who struggle the most. ***Ann Gervasoni*** *and Anne Roche* (Australia).
[2] Conceptual model-based problem-solving computer tutor for elementary students struggling in mathematics. ***Yan Ping Xin****, Soo Jung Kim, Bingyu Liu, Qingli Lei, Shuang Wei, Wudong Wang, Sue Richardson, Signe Kastberg, and Yingjie Chen* (USA).
[3] Interventions in micro-spaces for learners with mathematics difficulties. ***Robyn Ruttenberg-Rozen*** *and Ann LeSage* (Canada).
[4] An inclusive child’s enactment to a task in dynamic geometry environment. ***Shajahan Haja-Becker*** (Germany).
[5] The effect of schema-based instruction on the resolution of addition problems by a student with autism spectrum disorder. ***Irene Polo-Blanco****, Steven Van Vaerenbergh, Maria González, and Alicia Bruno* (Spain).
[6] Emergent technological practices of middle year students with mathematical learning disabilities. ***Alayne Armstrong*** (Canada).
[7] Introduction to probability in an inclusive setting — insights by a student with learning difficulties. ***Nadine da Costa Silva*** (Germany).
[8] Preparing teachers for mathematics and special education consultations. A collaboration across four continents. ***Sarah Van Ingen*** (USA)*, Samuel Eskelson* (USA)*, David Allsopp* (USA)*, Steffen Siegemund* (Germany)*, Anna-Sophia Bock* (Germany)*, Vera Lúcia Messias Fialho Capellini* (Brazil)*, Ana Paula Pacheco Moraes Maturana* (Brazil)*, and Di Liu* (China).
[9] Criteria used by teachers to identify students with difficulties in learning mathematics. ***Shemunyenge Hamukwaya*** (Namibia).
[10] Becoming a mathematician: The role of learning environments in the identity narratives of mathematics students with learning disabilities. ***Juuso Nieminen*** (Finland).
[11] Tactile drawings and 3-D objects: Two keys to geometry for a blind student in an inclusion university course for preservice K-8 teachers. ***Patricia Baggett*** (USA).
[12] Arithmetical achievements of children with Trisomy 21 supported on geometrical basis. *José Ignacio Cogolludo-Agustín,* ***Elena Gil-Clemente****, and Ana Millán Gasca* (Spain).
[13] Beyond ability rankings: Educational assessment as relational rigor and accountability. ***Anette Bagger****, Alexis Padilla, and Paulo Tan* (Sweden).
[14] Mathematics and blind students: The problem of representations. ***Elisabete Marcon Mello*** (Brazil).
[15] Mathematics difficulty of students with special needs from the perspective of memory theories. ***Chi To Lui*** *and Ida Ah Chee Mok* (Hong Kong SAR, China).
[16] A teacher’s attitude and approaches to high and low achieving students. *Julie Vangsøe Færch, Signe Gottschau Malm, and* ***Steffen Overgaard*** (Demark).
[17] Intervention based on mathematical thinking improves student outcomes: Math disabilities and difficulties. ***Jessica Hunt*** *and Kristi Martin* (USA).
[18] The variety of mathematical braille notations and their underlying principles. ***Annemiek van Leendert****, Michel Doorman, Johan Pel, and Johannes van der Steen* (The Netherlands).

2. Themes

Although there was a large variety in research topics presented during the sessions, the majority of the work can be summarized across four themes. First, a few research teams focused on supporting students who are visually impaired as they learn to symbolize in geometry, probability and other mathematical areas. For example, van Leendert's group[18] analyzed a variety of braille readers to see how they read and express mathematical notations and images. The results show that most of their ways of representing mathematics are very close to the graphical notation used by people who are not visually impaired or to the notation used in Excel or LaTeX. Baggett[11] shared a variety of manipulatives that were used to support a university student who is visually impaired as she learned geometry. And Marcon Mello[14] found that having students who are visually impaired draw their mental image of a mathematical object can reveal much more about their understanding than simply having them describe an already-drawn object.

A second theme that arose across the sessions involved advocating for a strengths-based, critical approach to both teaching and research with students with special needs. In particular, Bagger's group[13] argued that local and national assessments have been used to marginalize students with disabilities and make a compelling case for disrupting that deficit narrative. Hamukwaya[9] explored the criterion that teachers use to determine if a student has mathematics difficulties, while Færch's team[16] showed how a teacher's knowledge that a student was either high or low achieving impacted the quality of instruction given to them. Finally, Nieminen[10] interviewed university mathematics students to explore their social and cultural identities as mathematics majors and what experiences led to those identity formations.

In a related theme on identity and asset-based approaches to teaching mathematics to students with special needs, many participants argued that traditional research and teaching that focuses solely on developing students' procedural knowledge is inequitable to students with disabilities. Rather, students with disabilities should be engaged in mathematical sense making, like their regular education peers. Hunt and Martin developed an instructional unit for fractions that builds on constructivist learning progressions as did Gervasoni and Roche[1] for elementary students. Ruttenberg-Rozen and LeSage[3] introduced the term *microspace* and argued that students with disabilities should engage in these small, micro instances of sense making that, over time, build conceptual understanding. Cogolludo-Agustín's group[12] and Polo-Blanco's group[5] each showed how instructional units focusing on students' sense making in elementary concepts can improve students' with special needs mathematical understanding.

Finally, several research teams explored the use of manipulatives and technologies with students with disabilities. Xin and colleagues[2] created a computer tutor program to help students with learning disabilities/difficulties make sense of additive word problem solving after priming their early number concepts while Haja-Becker[4] found that students only partially used the provided technology when given the choice.

Similarly, Armstrong interviewed middle school students with disabilities to learn what types of mathematics technologies they regularly use besides calculators and found that students do not utilize assistive technologies much outside of the classroom.

3. Areas for Future Research

On the final day of the conference, the participants discussed three potential future research topics. First, we wondered what kinds of assistive or instructional technology are widely available to *simultaneously* support a particular need a student might have and would also engage them in mathematical sense making. Many technology programs facilitate procedural fluency but are not as strong in developing deep conceptual understanding (an exception is the computer tutor developed by Xin and colleagues[2]). How can we attend to both when designing technology for students with special needs and for inclusive purposes (i.e., technologies that are accessible to all students)? What kind of design principles are needed to strengthen such technologies and what research needs to be conducted in order to better understand their impact?

Participants also noted that there continue to be a relatively small number of research studies conducted in classroom settings. With the exception of da Costa Silvas' findings[7] regarding a student's learning of probability in an inclusion classroom, there were no other studies that explored students' learning in the context of a classroom with a teacher with multiple students learning together, such as in an inclusion setting.

Another research strand that was under-represented at the conference concerned supporting teachers in their work as both regular and special educators. Van Ingen and colleagues[8] presented a framework to describe the complex knowledge necessary for teachers to support their students with mathematics difficulties. Their singular work suggests that much more research is needed to determine the types of professional development and university preparation that is needed to support the work that teachers do with students who are struggling in mathematics.