

## Topic Study Group 29

### Preservice Mathematical Teacher Education at Secondary Level

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**ABSTRACT** Topic Study Group 29 (TSG-29) addressed preservice secondary mathematics teacher education. Its aim was to engage participants in sharing and discussing significant new trends and development in research, theory, and practice related to the various aspects of the initial education of secondary mathematics teachers. This report includes the themes of the TSG, overview of the TSG program, themes of the presentations, and future directions for research.

*Keywords:* Secondary preservice teachers; Mathematics teacher education; Topic Study Group.

#### 1. TSG-29 Aims and Themes

##### 1.1. Aims

The aim of Topic Study Group 29 (TSG-29) was to engage participants in sharing and discussing of significant new trends and development in research, theory, and practice related to the various aspects of the initial education of secondary mathematics teacher. The intent was to offer a program consisting of an overview of the current state-of-the-art, invited contributions from experts in the field, presentations of high-quality research reports from an international perspective, and discussion of directions for future research. Through this program, participants were expected to learn about and discuss research studies from different countries as well as have opportunity to learn about practices used around the world in relation to the education of preservice secondary mathematics teachers such as similarities and differences in the formal

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mathematics education of teachers, types and routes of teacher education and pathways to certification, curricula of mathematics teacher education, and factors that can influence similarities or differences.

### 1.2. Themes

Five themes were selected to frame the program on Preservice Secondary Mathematics Teacher (PSMT) education and satisfy the aim of the TSG. The call for proposals invited submissions of papers on research that addressed the suggested topics or other related topics for each theme. Tab. 1 consists of the themes and related topics.

Tab. 1. TSG-29 themes and topics

<p>PSMT knowledge</p> <ul style="list-style-type: none"> <li>• Nature of PSMTs' content and pedagogical content knowledge</li> <li>• Theoretical and methodological frameworks for studying PSMTs' knowledge</li> <li>• Development of PSMTs' knowledge during teacher education</li> <li>• Relationship between PSMTs' knowledge and their practices</li> </ul> <p>PSMT professional beliefs and identities</p> <ul style="list-style-type: none"> <li>• Theoretical and methodological frameworks for studying PSMTs' professional identities</li> <li>• Experiences contributing to the development of PSMTs' identities</li> <li>• Experiences contributing to changes in PSMTs' professional beliefs during preservice education</li> <li>• Relationship between PSMTs' practicum teaching and professional identity</li> <li>• Nature of PSMTs' productive disposition</li> </ul> <p>PSMT field experience</p> <ul style="list-style-type: none"> <li>• Effective teaching practices</li> <li>• PSMTs' experiences in mathematics classrooms and issues related to their school placements</li> <li>• Mechanisms that foster bidirectional relationships between partner schools and higher education institutions to support PSMTs in their field experiences</li> <li>• Experiences that PSMTs should have prior to student teaching</li> <li>• Activities to help PSMTs to become reflective practitioners during student teaching</li> <li>• Different types of field experiences required for PSMTs' certification</li> <li>• Best practices for preparing mentor teachers to work with PSMTs</li> </ul> <p>Technologies tools, and resources</p> <ul style="list-style-type: none"> <li>• Characteristics of technology, pedagogy and content knowledge (TPACK), development and assessment of PSMTs' TPACK</li> <li>• Video cases and online interactive environments that support PSMTs' learning</li> <li>• Mathematics tasks, textbooks, and other curriculum materials to support PSMTs' learning</li> <li>• Assessment tools used in PSMTs' mathematics education programs</li> <li>• Tasks to assess PSMTs' mathematics knowledge for teaching</li> </ul> <p>Teacher educator knowledge</p> <ul style="list-style-type: none"> <li>• The nature of mathematics teacher educators' knowledge for teaching PSMTs</li> </ul>
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## **2. TSG Program Overview**

The TSG-29 program was based on the proposals submitted and the presenters who were able to participate in the online sessions. The following overview of the program outlines the TSG's submissions, format, presentations, and presentation themes.

### ***1.3. Submissions***

The call for submissions to the TSG resulted in 51 proposals: four from invited presenters, 40 for oral presentations, and seven for poster presentations. The paper and poster proposals were reviewed by two reviewers — one from the organizing team and one from the list of authors. Based on the reviews, 17 papers were accepted as long oral presentations, 18 as short oral presentations, and 12 as posters. The invited paper proposals were reviewed by the organizing team to provide feedback to the authors. The final breakdown of the 51 proposals accepted consisted of: 4 invited presentations; 17 long oral presentations; 18 short oral presentations; and 12 poster presentations.

### ***1.4. Format***

The initial plan was to structure the TSG program based on the TSG themes (Tab. 1). However, this plan was revised when several participants indicated that they were not able to attend the online conference. The remaining papers were not well distributed among the TSG themes, which made organizing them into meaningful discussion groups across the three sessions impractical. The final format of the program consisted of individual presentations ranging from eight to 20 minutes depending on whether long or short oral or invited. There was limited interaction and discussion of questions due to the tight timeframes for the presentations and the online setting. Each session was opened by the chair of the organizing team, Olive Chapman, and chaired by one of the team members. For the first session (120 minutes), Tracy Helliwell chaired the first hour with five presentations and Jing Cheng chaired the second hour with five presentations. Benita Nel chaired the second session (90 minutes) with six presentations and Immaculate Namukasa chaired the third session (90 minutes) with six presentations.

### ***1.5. Oral presentations***

Of the 39 accepted oral presentation submissions to the TSG, only 22 were presented during the online conference because some authors were unable to attend. Tab. 2 consists of the oral presentations given at the conference. In the table, IT stands for Invited Talk, LO for Long Oral presentations, and SO for Short Oral presentations. It is organized alphabetically within the different categories of presentations. Each session consisted of at least one invited presentation, one long oral presentation, and two short oral presentations.

Tab. 2. TSG-29 Oral presentations

<b>Paper and author(s)</b>	
[1]	Using multiple scripting tasks to probe preservice secondary mathematics teachers' understanding of visual representations of function transformations. <b>James Mendoza Álvarez, Theresa Jorgensen, and Janessa Beach</b> (USA). (IT)
[2]	Measuring prospective secondary mathematics teachers' knowledge. <b>Kim Beswick</b> (Australia). (IT)
[3]	A case study on the development of pedagogical design capacity of mathematics prospective. <b>Meiyue Jin</b> (China). (IT)
[4]	Mentor teachers as inductors of preservice mathematics teachers at secondary schools. <b>Kakoma Luneta</b> (South Africa). (IT)
[5]	Developing an identity as a mathematics teacher: connecting with the community of teacher graduates. <b>Judy Anderson and Debbie Tully</b> (Australia). (LO)
[6]	Teacher educators' use of technology to represent instruction. <b>Daniel Chazan and Patricio Herbst</b> (USA). (LO)
[7]	Tertiary and secondary mathematical knowledge for prospective teachers: a comparison of teacher employment tests for secondary math in Korea and China. <b>Xiaoying Chen and Bomi Shin</b> (South Korea). (LO)
[8]	Developing preservice teachers' ability to enact formative assessment for mathematical practices. <b>Jacqueline Coomes</b> (USA). (LO)
[9]	A situated approach to assess prospective mathematics teachers' professional competencies. <b>Le Thi Bach Lien and Tran Kiem Minh</b> (Vietnam). (LO)
[10]	Transforming secondary mathematics teacher preparation: a multi-dimensional problem. <b>Gary Martin and Marilyn E. Strutchens</b> (USA). (LO)
[11]	Instrumental genesis and the growth of preservice secondary mathematics teachers' technological content knowledge. <b>Xiangquan Yao</b> (USA). (LO)
[12]	Prospective secondary mathematics teachers' learning of problem solving and modelling for teaching. <b>Olive Chapman</b> (Canada). (SO)
[13]	Direct and indirect effect sizes on secondary mathematics teacher candidates' content knowledge & pedagogical content knowledge as measured by national examinations. <b>Jeremy Żelkowski and Tye Campbell</b> (USA). (SO)
[14]	Emotional awareness and support for preservice teachers during micro-teaching. <b>Réka Szász</b> (Hungary). (SO)
[15]	Teacher candidates' and mentor teachers' perspectives of using co-planning and co-teaching during clinical experiences in secondary mathematics. <b>Ruthmae Sears, Cynthia Castro-Minnehan, Laurie Riggs, Pier Junor Clarke, Jamalee Stone, Charity Cayton, Maureen Grady, Jennifer Oloff-Lewis, Patricia Brosnan, and Marilyn Strutchens</b> (USA). (SO)
[16]	Should school and university mentors agree in their feedback to pre-service mathematics teachers? <b>Viren Ramdhany</b> (South Africa). (SO)
[17]	Physical representations and understanding of multivariate functions. <b>M. Kathleen Heid and Matthew Black</b> (USA). (SO)
[18]	Developing prospective teachers' knowledge to promote students' mathematical reasoning: design of a teacher education experiment. <b>Ana Claudia Henriques, Hélia Oliveira, Leonor Santos, and Henrique Guimarães</b> (Portugal). (SO)
[19]	A case study on applied lesson study for Korean secondary pre-service teachers. <b>Na Young Kwon</b> (South Korea). (SO)
[20]	Investigating the professional learning of pre-service mathematics education students using reflection and collective feedback to enhance teaching. <b>Benita Portia Nel</b> (South Africa). (SO)
[21]	Concept cartoon design in preservice teacher training: an opportunity to learn from the practice. <b>Cristina Ochoviet</b> (Uruguay). (SO)
[22]	Integrating computational making tools in mathematics thinking activities. <b>Immaculate Namukasa, George Gadanidis, and Derek Tangredi</b> (Canada). (SO)

### 1.6. *Poster presentations*

Of the 12 posters accepted, only six were presented at the conference. The other authors were unable to attend the online conference. The poster presentations occurred during a separate poster session and not as part of the program of this TSG. Tab. 3 consists of the posters that were presented.

Tab. 3. TSG-29 Poster presentations

<b>Paper and author(s)</b>
[23] Online live teaching of mathematics methodology course with tencent classroom. <i>Peijie Jiang and Bin Xiong</i> (China).
[24] Common construction of pre-service mathematics teachers practical capacity. <i>Xiaofeng Lan, Ying Zhou</i> (China), and <i>Tommy Tanu Wijaya</i> (Indonesia).
[25] Pre-service teachers problem solving in trigonometry. <i>Kristi Renea Martin</i> (USA).
[26] Encouraging student success: exploring the use of technology based pedagogic strategies within mathematics higher education milieus. <i>Jayaluxmi Naidoo</i> (South Africa).
[27] Development of TPACK of preservice secondary mathematics teachers. <i>Mária Slavičková</i> (Slovakia).
[28] A didactic model to favor the positive use of error in the initial teacher training. <i>Oswaldo Jesus Rojas Velazquez and Carlos Berrío Pérez</i> (Colombia).

### 1.7. *Themes of oral presentations*

The areas of research covered in the TSG oral presentations addressed seven themes regarding PSMT education. Each theme was addressed in different ways by the studies.

Theme 1 studies focused on the development of the knowledge and ability of PSMTs, which received the most attention by the presentations. The studies included investigations of the following topics: (i) Development of the PSMTs' ability to understand and enact formative assessment as a way to leverage mathematical practices for student learning. (ii) Development of the PSMTs' mathematical and didactical knowledge to promote students' mathematical reasoning. (iii) Use of applied lesson study to help PSMTs to learn about teaching. (iv) A technique involving emotion cards used to give emotional support to PSMTs during micro-teaching. (v) Multi-dimensional issues faced by PSMT preparation programs. (vi) PSMTs' learning through designing and using open-ended concept cartoons. (vii) Supporting PSMTs' learning of problem solving and modelling for teaching.

Theme 2 studies addressed measuring PSMT knowledge. They investigated ways of measuring/assessing the PSMTs' knowledge for teaching mathematics; professional competencies for teaching mathematics from a situated perspective; content and pedagogical content knowledge based on national examinations; and mathematical knowledge based on teacher employment tests for secondary mathematics.

Theme 3 studies focused on PSMT field experience. They investigated: (i) PSMTs' learning using reflection and collective feedback of practice teaching to enhance teaching; (ii) practicum experiences of PSMTs supervised by school and university mentors; and (iii) PSMTs' and mentor teachers' perspectives of using co-planning and co-teaching during practicum.

Theme 4 studies focused on PSMT content knowledge. They explored: (i) the PSMTs' understanding of visual representations of function transformations and capacity to connect multiple representations of functions and (ii) the PSMTs' physical representations and understanding of multivariate functions. One study used a method involving multiple scripting tasks to conduct the exploration.

Theme 5 studies focused on PSMT teacher educators. They investigated: (i) a training program around mathematics teacher induction and mentorship of PSMTs and (ii) PSMT teacher educators' use of technology to represent instruction and facilitate collaboration on both teaching and research.

Theme 6 studies focused on PSMTs' use of technology. They explored: (i) PSMTs' integration of "computational making tools" in mathematics thinking activities in teaching mathematics and (ii) types of technological content knowledge emerging in the process of instrumental genesis when PSMTs engaged in problem-solving with the Geometer's Sketchpad.

Theme 7 focused on identity. It consisted of only one study that investigated a strategy to build community of practice to support PSMTs' development of identity as a mathematics teacher.

### 3. Future Directions for Research

Research on mathematics teacher education continues to be of importance to support international efforts to reform mathematics education for a digital and changing world. As reflected in the number of submissions to this TSG, there is high level of interest in engaging in research on PSMT. The presentations and the themes of the TSG suggest future directions for ongoing research on PSMT. Tab. 4 presents summaries of the TSG themes and the themes emerging from the oral presentations to highlight how they are related. While all of the topics for the TSG themes (Tab. 1) are important to guide future research of PSMT education, the following discussion focuses on aspects of them that overlap with the presentation themes as outcomes of the TSG program with implications for future directions of research.

Tab. 4. Summary of themes of TSG-29 and oral presentations

TSG-29 themes	Themes of oral presentations
PSMT knowledge	Exploring PSMT content knowledge
	Development of PSMT pedagogical knowledge
PSMT professional beliefs and identities	Development of PSMT identity
PSMT field experience	Field experience
Technologies, tools, and resources	Measuring PSMT knowledge
	Technology
Teacher educators' knowledge	Teacher educators

PSMTs' knowledge for teaching mathematics (the first TSG theme) is central to teacher education programs. Thus, ongoing research is necessary to offer further insights of the nature of this knowledge and instructional approaches to effectively

support the PSMTs' development of it. The TSG presentations included studies that explored PSMTs' knowledge of functions and the use of unique ways of conducting the exploration. The presentations also included studies that investigated PSMTs' development of different aspects of their pedagogical ability (e.g., use of formative assessment; promoting mathematical reasoning) and instructional approaches to support PSMTs' learning of pedagogical knowledge for mathematics (e.g., use of lesson study; emotion cards; concept cartoons). Based on these studies, one implication for future research is consideration of different mathematics content topics associated with secondary school curricula and of innovative approaches to explore these topics to offer alternative ways of understanding PSMT content knowledge for teaching. Another implication is the need for further research to deepen our understanding of: (i) the development of different aspects of PSMTs' pedagogical ability and (ii) innovative, effective approaches to support PSMTs' development of both pedagogical ability and pedagogical content knowledge for mathematical practices.

The TSG theme of PSMT professional beliefs and identities was the least represented by the TSG presentations. One study addressed the development of PSMTs' identity through community of practice. However, while math-related beliefs have received lots of attention in research, the same has not been the case for identity, which is also an important component in defining the mathematics teacher. Thus, identity remains an area that should receive more attention in future research on PSMT.

The TSG theme of technologies, tools, and resources highlights specific ways (e.g., use of digital tools, mathematical tasks, textbooks) of engaging PSMTs in their learning and ways of measuring the level of what they learned or know. The TSG presentations included studies that addressed technology in the context of exploring PSMTs' use of "computational making tools", PSMTs' technological content knowledge, and teacher educators' use of technology in instruction. The presentations also included studies that addressed ways/tools of measuring or assessing content and pedagogical knowledge (e.g., performance measures; a situated perspective framework; national examinations; teacher employment tests). The implications from this group of studies is that more attention is needed on this TSG theme in future research to explore it with more breadth and depth. For example, future research could further investigate innovative and effective ways for integrating technology in teacher education and tools for determining the quality of PSMT mathematics knowledge for teaching to inform teacher education. The current pandemic also opens up the importance of considering and researching its impact on PSMTs' education regarding what technological knowledge they should hold (e.g., regarding remote learning) and how to support their learning of it.

The TSG theme of PSMT field experience highlights another central area of PSMTs' education that requires ongoing attention in research. The TSG presentations included studies that investigated PSMTs' learning using reflection and collective feedback of practicum teaching to enhance it, PSMTs and mentor teachers working together, and joint supervision of PSMTs by school and university mentors. Thus, implications for future research include the need to further investigate innovative,



effective ways for PSMTs to learn from their field experiences and the types of practices under university and school advisors that are best for practicum experience.

The final TSG theme is teacher educator knowledge, which recently has been receiving growing attention in research. The TSG presentations included studies that investigated an education program for PSMTs' mentor teachers and how teacher educators represented classroom interaction through use of digital tools. Based on this theme, implications for future research on teacher educators at school or postsecondary levels include exploration of innovative, effective approaches or programs to support their development of knowledge for teaching PSMT; the nature of the content and pedagogical content knowledge needed to prepare PSMT in the context of a digital age and changing world; and alternative approaches to researching this knowledge. For example, self-based methodologies (Chapman et al., 2020) such as narrative inquiry and self-studies need more attention as promising ways of exploring and understanding mathematics teacher educators.

Other important areas of PSMT education that should be addressed in future research but not explicitly addressed in the TSG themes include the following: (1) The cooperation between mathematicians and educational researchers is of value in the field of mathematics education, in general, and PSMT education, in particular. Thus, research needs to explore how mathematicians could play a more important role in PSMT education in addition to teaching advanced mathematics courses. (2) Different countries and regions have rich theories and practices in PSMT education. Research should explore new paths of international cooperation in addressing these theories and practices for the benefit of the international field of PSMT education. (3) Preservice teacher education is closely related to previous primary/elementary and secondary school education and subsequent in-service teacher professional development. Thus, research should attend to the correlations and connections among the three in the context of PSMT education. (4) The development of artificial intelligence is constantly changing people's way of life and even the way students learn inside and outside schools. Research should attend to what should or would happen to the content and methods of PSMT education in this changing context.

To conclude, TSG-29 was successful in achieving the goal of sharing meaningful, insightful research on PSMTs from around the world. Through the themes of the TSG and the themes of the paper presentations, the outcomes of the TSG offer implications for future research to advance the field of PSMT education. In general, research needs to address PSMT education in the context of a digital age and rapidly changing world.

## References

- O. Chapman, E. Suazo-Flores, D. Cox, S. Kastberg and J. Ward (2020). Mathematics Teacher Educators' Inquiry into Their Practice. In: K. Beswick and O. Chapman (Eds.), *International Handbook of Mathematics Teacher Education: The Mathematics Teacher Educator as a Developing Professional* (2nd Edition, vol. 4. pp 157–190). Leiden, The Netherlands: Brill-Sense.