Topic Study Group 40

Research and Development on Mathematics Curriculum

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ABSTRACT The theme of Topic Study Group 40 (TSG-40) at the 14th International Congress on Mathematical Education (ICME-14) (Shanghai, China) is Research and Development on Mathematics Curriculum. TSG-40 was held worldwide on-line style in three sessions of July 13, July 16, and July 17, 2021. This article reports a concise summary of TSG-40 including its organization, theme and description, the list of presentations and program overview, the summary of presentations in the theme of four topics at TSG-40, and future directions and suggestions in the area of research and development on mathematics curriculum.

Keywords: Mathematics Curriculum; Policy; Research; Development.

1. Organization, Theme, and Description of TSG-40

1.1. Organization and Theme of TSG-40 for ICME-14

TSG-40 was organized by the organizing team[3].

The theme of TSG-40 at ICME-14 is Research and Development on Mathematics Curriculum. Its aim is to share and discuss the recent results of research and development on mathematics curriculum at all levels, and to identify perspectives for future research and development. Recent mathematics curriculum study has expanded to explore a range of important topics, including policy issues, curriculum development and analysis, and curricular impact on teachers' teaching and students' learning (Li and Lappan 2014, Vistro-Yu and Toh 2019).

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1.2. Description of TSG-40

We called for papers for TSG-40 as follows.

TSG-40 welcomes researchers, teacher educators, teachers, curriculum developers, test developers, and policy makers with research interests in research and development on mathematics curriculum. We invite both theoretical and empirical research contributions that address one or more of the following topics in the research and development on mathematics curriculum.

Topic 1: Mathematics Curriculum Policy

This topic includes policy issues related to mathematics curriculum in different education systems, and the process of curriculum decision-making, curriculum changes, curriculum policy, and education changes viewed from a historical perspective.

Topic 2: Mathematics Curriculum Development and Analysis

This topic includes curriculum design and development in different education systems, explicating and comparison of diverse ideas and practices in curriculum development, textbook design, and changes in curriculum development in different system contexts.

Topic 3: Mathematics Curriculum, Teacher, and Teaching

This topic includes perspectives on the process of improving mathematics education by reform of curriculum and teaching, and the challenges of developing, implementing, and evaluating change in the content objectives and teaching of mathematics.

Topic 4: Mathematics Curriculum and Student Learning

This topic includes curricular impact on students' learning and the challenges of reforming the curriculum to improve students' learning.

2. List of Presentations at TSG-40 and Program Overview of TSG-40

2.1. List of presentations at TSG-40

As a result of both peer-reviews and the payment of registration fee for participating in ICME-14, TSG-40 contributions included 1 long paper (LO), 10 short papers (SO) and 3 posters. Tab. 1 (on the next page) lists the title and author(s) of the papers and posters presented at TSG-40.

2.2. Program Overview of TSG-40

TSG-40 had three sessions with 90-90-120 minutes' timeslots for papers. We gave a careful consideration to the worldwide on-line style of TSG-40 especially the time difference and made the program of presentations at TSG-40 including an opening session in Session 1 and a closing session in Session 3 as follows.

Tab. 1. List of papers and posters presented at TSG-40

Title and *author(s)*	
[1]	Identifying the quality of teacher created curriculum shared via the teachers' pay teachers online platform. *Lara K. Dick, **Amanda G. Sawyer**, and Margaret A. MacNeille* (USA). (LO)
[2]	Comparative study on statistical contents in Chinese and Japanese mathematics textbooks. ***Xinqi Zhang** and Masataka Koyama* (Japan). (SO)
[3]	The implementation of a reformed mathematics curriculum: Mathematical processes in practice. ***Anna Klothou** and Charalampos Sakonidis* (Greece). (SO)
[4]	The mathematical literacy in Korean mathematics curricula. ***Eun Young Cho** and Rae Young Kim* (South Korea). (SO)
[5]	Financial education in the Romanian mathematics curriculum: Policy and implementation in elementary textbooks. ***Daniela Căprioară*** (Romania), *Annie Savard, and Alexandre Cavalcante* (Canada). (SO)
[6]	Formative evaluation of a tool for representing ideas in mathematics curriculum design: A Delphi study example. ***Ellen Jameson** and Lynne McClure* (UK). (SO)
[7]	Images of mathematics curriculum and pedagogical influences. ***Laxman Luitel** and Bal Chandra Luitel* (Nepal). (SO)
[8]	A participative approach to designing a new mathematics course for all college and university students in the Philippines. ***Catherine P. Vistro-Yu*** (Philippines). (SO)
[9]	A comparison of U.S. and Chinese geometry strands through the lens of van Hiele. ***Lili Zhou**, Jinqing Liu, and Jane-Jane Lo* (USA). (SO)
[10]	Curriculum proposal from El Salvador for improving math learning, description, structure, first results and effectiveness. ***Francisco Antonio Mejia Ramos*** (EI Salvador). (SO)
[11]	A course design for mathematical modeling in high school based on STEM education. ***Shengkui Su**, Lin Miao, and Qinghua Chen* (China). (SO)
Posters	
[12]	Investigating third level lecturers awareness of second level curriculum reform four years on. ***Fiona Faulkner**, Cormac Breen, Michael Carr, and Mark Prendergast* (Ireland).
[13]	Mathematical curriculums for five-year junior college programs in Taiwan. ***Yu Jr Tsai** and Shao Ying Li* (Chinese Taipei).
[14]	The curricular statute of the discrete mathematics discipline in the Brazilian systems analysis and development public technological course. ***Jefferson Biajone** and Vinicio de Macedo Santos* (Brazil).

- Session 1 (Tuesday July 13) 19:30~21:00 Beijing time (90 minutes), only one long oral presentation[1];
- Session 2 (Friday July 16) 21:30~23:00 Beijing time (90 minutes), six short oral presentations[2—7];
- Session 3 (Saturday July 17) 14:30~16:30 Beijing time (120 minutes), four short oral presentations[8—11];
- Poster Session (Saturday July 17) 13:00~14:00 Beijing time (60 minutes), three posters[12—14]

The authors came from 13 countries — Brazil, Canada, China (including Chinese Taipei), El Salvador, Greece, Philippines, Ireland, Japan, Nepal, Romania, South Korea, UK, and USA — representing the different parts of the world. In the next section 3, we will classify and summarize the all 14 presentations into the theme of four topics at TSG-40.

3. Summary of Presentations in Theme of Four Topics at TSG-40

3.1. Topic 1: mathematics curriculum policy

We had four presentations related to the theme of mathematics curriculum policy.

Klothou and Sakonidis[3] examined six primary school teachers' practices concerning four mathematical processes adopted after their involvement with piloting a reformed mathematics curriculum in Greece. Analysis of the data revealed contradictions in teachers' teaching practices which can be attributed to local recontextualization procedures activated during the implementation of the reformed curriculum. Căprioară et al.[5] focused on the introduction of financial education in the school curriculum. As the introduction occurs in many ways depending on educational policies and systems, they showed to what extent the Romanian mathematical curriculum for the primary level corresponds to the concepts derived from the definitions of financial education. The recent mathematics curriculum requires teaching a lot of financial concepts. So, they insisted the elementary school teachers play an important role though they have not been trained to teach financial learning, even if they are currently being asked to do so.

Tsai and Li[13] showed the arrangement of mathematical curriculum in five-year junior college programs which combines with compulsory education and higher education in Taiwan. No matter what schools are, achievement gap caused by the system of mathematical curriculum in compulsory education can be clarified effectively after analyzing mathematical curriculum guidelines. They suggested this may help teachers to understand the contents students are learning in class, and moreover, teachers can find some proper strategies to assist interdisciplinary students to learn mathematics effectively. Biajone and Santos[14] presented research on the statute of the discrete mathematics (DM) course curriculum production in terms of objectives and contents for the system analysis and development (SAD) undergraduate course offered by 134 public technological colleges and universities in Brazil. Developed in 2018, they investigated the DM discipline constitution at the undergraduate level according to what contents and purposes are needed for the SAD course and its prescribed curriculum under the perspective of curriculum policy cycle and history of disciplines.

3.2. Topic 2: mathematics curriculum development and analysis

Mathematics curriculum development and analysis was an important theme at TSG-40. We had six presentations related to the theme.

There were two presentations of comparative study in the theme. Zhang and Koyama[2] compared the statistical contents in Chinese and Japanese mathematics textbooks as a part of intended mathematics curriculum. The similarity and difference were reflected on the structure of statistical contents and means of data analysis. There were deficiencies in problems, plans and conclusions of the statistical investigative cycle in China and Japan. Therefore, they suggested that we can use mathematical

history materials of statistics to help students promote statistical thinking process. Zhou et al.[9] compared the geometry standards in U.S. Common Core State Standards of Mathematics (CCSSM) and Chinese Compulsory Education Mathematics Curriculum Standards (CMCS) through the lens of van Hiele levels. By examining the van Hiele level distributions of the learning expectations and major topics, they investigated how CCSSM and CMCS propose the development of the geometric thoughts of students. Implications of this study and suggestions for future revisions for both standards were discussed.

Cho and Kim[4] analyzed the nature of mathematics and the goals of mathematics education represented in 10 Korean mathematics curricula (from the 1st to the 2015 revised curriculum) to find out how the concept and meaning of mathematics have changed over time. They conducted semantic network analysis by keywords of each curriculum to identify the word change trend by extracting the frequency and degree centrality of each word, and matrix charts among words. On the other hand, Luitel and Luitel[7] assessed the beliefs about the mathematics curriculum and its pedagogical influences in classroom aiming to improve the teaching and learning environment. They followed metaphorical approach to represent the beliefs of mathematics curriculum. The knowledge constitutive interest, transformative learning theory and social constructivism were considered the major theoretical lenses. The moments and situations they experienced during their own teaching and learning activities has represented through multiple genres.

Ramos[10] showed the mathematics curriculum in El Salvador. Since 2016, El Salvador in cooperation with JICA has developed a new mathematics education policy. The proofreading strategy based on El Salvador students' needs, the rearrangement of contents in the courses of study, and the approach to specific classes were essentially explained. The implementation based on a 'student-centered approach' and a suitable 'teacher support' based on some specific formative assessment statements were briefly presented as well. Finally, some findings of the first years of implementation and apparent success were shown. Su et al.[11] focused on the strong correlation of mathematical modeling literacy among multiple disciplines in high school. They have built a progressive course system including mathematical modeling basic courses (M), innovation practice courses based on school-enterprise cooperation (I), research-based learning advanced courses (R) and STEM higher-order courses (S), jointly constituting the MIRS course. On this basis, they illustrated the implementation of the MIRS course through four course cases.

3.3. Topic 3: mathematics curriculum, teacher, and teaching

Mathematics curriculum, teacher, and teaching were also an important theme at TSG-40. We had three presentations related to the theme.

Dick et al.[1] studied on identifying the quality of teacher created mathematics curriculum. Teachers Pay Teachers claims to be "the world's most popular online marketplace for original educational resources." The Teachers Pay Teachers (TpT)

website offers more than five million free and paid resources and has over seven million teacher users. Despite the growing popularity of websites such as TpT, the mathematics education community knows little about the quality of these curricular resources. In their presentation, they sought to address this lack of knowledge for elementary mathematics. They shared results from a research study that compares 500 free vs. 500 paid elementary mathematics activities each with the highest rating found on TpT.

Vistro-Yu[8] described and analyzed the design process that went into the development of the new mathematics course for the general education curriculum (GEC) required of all students at colleges and universities in the Philippines, beginning SY 2018-2019. The new GEC was conceptualized in 2013 to accompany the new K-12 mathematics curriculum. Entitled "Mathematics in the Modern World" (MMW), this new course was envisioned to help provide for the holistic development of the Filipino student in tandem with courses from other disciplines. Proposals for a more systematic curriculum development process were offered. Faulkner et al.[12] made a further analysis of the transition of a second level curriculum reform to higher education in Ireland. At ICME-13, an initial study was presented by the authors investigating third level mathematics lecturers' awareness of the second level reform. The findings determined that although many lecturers were mindful of the concept of Project Math, they were not aware of the changes in full and how that affected their own course content, teaching, and assessment strategies. This study was a follow-up to the original, and comparisons were made with the 2015 data to see if the situation had changed.

3.4. Topic 4: mathematics curriculum and student learning

Although the relationship between mathematics curriculum and student learning was an important theme, there was one presentation related to the theme at TSG-40. Jameson and McClure[6] discussed some contributions of a Delphi study conducted for the formative evaluation of such a tool, the Cambridge Mathematics Framework. A panel of curriculum researchers responded to questions arising from the design, theoretical framework and methodology. Their presentation focused on the panel's responses regarding the contributions of motivation to mathematical thinking and doing. The panel assigned motivation lower priority in total for consideration in the design work, but also expressed the highest levels of professional disagreement about it.

4. Future Directions and Suggestions

The above-mentioned paper and poster presentations are classified into four topics of TSG-40 at ICME-40 as follows. The presentations[3,5,13,14] are related to the theme of *Topic 1* which includes policy issues related to mathematics curriculum in different education systems, and the process of curriculum decision-making, curriculum changes, curriculum policy, and education changes viewed from a historical

perspective. The presentations[2,4,7,9,10,11] are related to the theme of *Topic 2* which includes curriculum design and development in different education systems, explicating and comparison of diverse ideas and practices in curriculum development, textbook design, and changes in curriculum development in different system contexts. The presentations[1.8,12] are related to the theme of *Topic 3* which includes perspectives on the process of improving mathematics education by reform of curriculum and teaching, and the challenges of developing, implementing, and evaluating change in the content objectives and teaching of mathematics. The presentation[6] elated to the theme of *Topic 4* which includes curricular impact on students' learning and the challenges of reforming the curriculum to improve students' learning.

Many of the papers presented at TSG-40 are descriptive. As future directions and suggestions in the research and development on mathematics curriculum, it would be valuable to consider the design process, the process of implementation and assessing the effects on students, and to take a more critical perspective on the comparative work.

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