

Survey on Early Childhood Mathematics Education at ICME-14

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This paper is about a survey to be presented at the 14th International Congress on Mathematics Education, which addresses the latest developments on Early Childhood Mathematics Education. The relevance of early mathematics learning and teaching in mathematics education research is explained and an overview of the work done by the Survey Team on this specific theme is described.

At the 14th International Congress on Mathematics Education (ICME-14), which will take place in Shanghai from July 11 to 18, 2021, four surveys will be presented, addressing the latest developments on four particular themes of mathematics education, which are considered important for the ICMI community. The theme of one of these surveys is Early Childhood Mathematics Education (up to age 7). Our aim is to briefly present the relevance of this theme in mathematics education research as well as an overview of the work done by the Survey Team on this specific theme, which may be of interest for mathematics educators and also for mathematicians.

Research in early childhood mathematics education has experienced increasing growth over the last years. The interest in this field is induced mainly by the strong emphasis given on early childhood education in many countries and by the well documented, positive relation between children's early mathematical knowledge and their later success in mathematics learning [2]. The high importance of early childhood education is acknowledged by countries all over the world. This is evident by the increase of their expenses and investments in early childhood education, and by their access to pre-primary education. The emergence of new curricula and higher demands in the quality of early childhood education staff is also manifest in a number of countries [4].

Regarding the association between children's early mathematical skills and their later mathematical achievement, there is clear evidence that when children enter school with high levels of knowledge they maintain these high levels at least through the end of primary school [5]. Research has also provided evidence for statistically significant links between mathematics ability in preschool and mathematics performance in adolescence [7]. Thus, establishing a solid foundation for children's mathematical development before they even enter school plays a crucial role in their future learning.

The quality of early childhood mathematics education also affects children's later mathematical dispositions. Particularly, when approaches to mathematics education are meaningful and enjoyable for children, it is more likely that they will appreciate and engage in mathematics education later on [6]. Considering the decline in attitudes towards mathematics over the school years, starting already in the first years of school, and considering the fact that young children's mathematical knowledge and abilities influence their mathematical affect and dispositions [3], the need for high quality mathematics education in the early years deserves strong emphasis.

In the past few years, a great deal of attention within the field of mathematics education has been given to research on learning and teaching mathematics in early childhood. This is highlighted by the numerous publications on early childhood mathematics education, and by the many special interest or study groups in international mathematics education conferences devoted to this field that focus on the study of the learning and teaching processes in early childhood mathematics education and the environment in which these processes take place [1]. A vast amount of research has been undertaken for an even longer time in the related domains of developmental and cognitive psychology. This research has investigated early-year mathematics with a particular focus on the relationship between children's cognitive abilities (e.g., working memory, visuo-spatial abilities) and their early mathematical skills.

This survey has been designed to establish an in-depth and comprehensive review of the state-of-the-art of the most important developments and contributions since 2012, and of current tendencies, new perspectives and emerging challenges in early childhood mathematics education. The survey drew from a broad range of sources, including peer-reviewed journal articles in the above-mentioned disciplines, as well as international peer-reviewed conference proceedings, including ICME, the Conference of the International Group for the Psychology of Mathematics Education (PME), the Congress of the European Society for Research in Mathematics Education (CERME), ICMI Study Conferences and prominent research handbooks in the discipline of mathematics education. An annotated bibliography listed the papers that have been identified as relevant, leading to a comprehensive analysis of the issues

raised by this research literature and to a synthesis of the pertinent findings.

The survey focuses on six major research threads that have been identified in recent literature on early childhood mathematics education. Three of these threads are content-oriented: number sense and whole number development, geometry education, and children's competences in other content domains. A twofold cognition-oriented thread focuses on cognitive skills and special education, respectively, in early childhood mathematics. The role of technologies in early mathematics teaching and learning is another important research thread that is systematically reviewed. Finally, a teacher-oriented thread presents a synthesis of results of recent studies on early childhood teachers' knowledge, education and affective issues in mathematics.

The review of research on the content-oriented threads reveals a common threefold focus across these threads: firstly, on offering insights into young children's competences and development in these content domains, secondly, on identifying influences of certain abilities into children's development, and thirdly, on proposing and investigating the effectiveness of programs or interventions on children's learning. The review of literature on cognitive skills involved in mathematical learning has a particular focus on the learning of numbers and arithmetic from as early as toddler stage, and reveals that processing quantities can be done very early in life through non-verbal innate mental systems. Moreover, visuo-spatial abilities, working memory, finger gnosis, or cognitive flexibility are only some of the key cognitive skills in young children that have been found to be predictive of or associated with mathematical performance. The review of research on the use of technology in early childhood mathematics education highlights how specific forms of interactivity available in multi-touch technology or with programmable robots can be used to enhance mathematical learning. Regarding the teacher-oriented thread, studies on the professional development of early childhood teachers in mathematics focus on enhancing teachers' knowledge of children's mathematical abilities and reasoning, thus influencing teachers' beliefs regarding young children's mathematics learning.

Overall, our work on this survey has shown that there is a plethora of research on early childhood mathematics education and that there will be continued growth and important progress in this field in the years to come. Among the six threads of our survey review, some, e.g., whole number development, cognition-oriented threads, have been studied more extensively than others, e.g., geometry education, other content domains, teacher-related issues. All these threads reflect new areas of development, e.g., use of technological tools, embodied learning, interventions for teachers, comparative studies, as well as more ordinary research topics, e.g., mathematical competences, problem solving, language. We expect that there will be continued growth in all these areas with specific emphasis on the under-researched and more recent areas of study.

The findings of the survey will be presented and discussed in more detail at ICME-14, on July 18, 2021.

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