Research on the Phenomenon of Acceleration in Mathematics during the Primary Period in China

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Abstract. Mathematics education plays a pivotal role in the learning process of primary school students, significantly influencing their numerical comprehension, logical thinking abilities, and the development of their worldviews, life perspectives, and values. However, as social progress accelerates and the concept of "accelerated education" becomes more prevalent, there is an increasing concern regarding the impact of acceleration in mathematics learning in primary schools on children's overall development. However, there is a gap in academic research. Based on existing literature, this paper reveals that acceleration in mathematics learning in the primary period deviates from children's cognitive developmental patterns and hampers their proximal development to some extent. Moreover, it does not foster long-term growth in rational thinking skills or scientific spirit and intelligence. This study proposes several suggestions to address this phenomenon effectively, like encompassing innovative teaching methods, improving teaching content, and interdisciplinary evaluation approaches. These recommendations include selecting appropriate teaching materials and cultivating a classroom environment that encourages questioning. The aim is to provide essential theoretical foundations for national policymakers while harnessing the potential of mathematics education to bridge existing academic gaps.

Keywords: Acceleration in mathematics, Primary period, Rational thinking, Scientific spirit, Intelligence development.

1. Introduction

Mathematics is a crucial subject that forms an integral part of primary school education. It plays a vital role in developing number sense, logical thinking, and innovation consciousness. According to the recently released 2022 curriculum standards for mathematics in compulsory education in China, modern mathematics has become the foundation of all-natural and social sciences. It has unique laws and values and is an abstraction of the real world. In terms of children's growth and development, mathematics allows them to gain a deeper understanding of the world while acquiring essential knowledge, skills, ideas, and practical experiences necessary for adapting to modern life and pursuing further studies [1]. Mathematics also fosters the development of children's rational thinking, scientific spirit, and intellectual development, which enhances children's sense of social responsibility while helping them establish a correct worldview, lifestyle perspective, and values [1].

However, as society progresses, there has been a growing emphasis on ensuring children's competitive advantage and striving for excellence in mainstream parenting concepts. It has led to an observable increase in the acceleration of mathematics education in economically developed areas like Beijing (especially Haidian District, a cluster of critical schools), Shanghai, and Shenzhen. Furthermore, incidents involving primary school students studying calculus have surfaced, prompting people's contemplation on the mathematics content in the compulsory stage, especially during the primary period.

According to Piaget's theory of cognitive development, kindergarten children are mainly in the pre-operational stage, while primary school children are in the concrete and formal operational steps [2]. It means that before starting primary school, most children should be able to think about objects and events using mental representations. Kindergartens should use game exploration to help children establish comprehension and cognition, enabling them to connect better with abstract mathematical symbols [3]. This approach allows children to gradually learn abstract mathematics from tangible reality, making it easier for them to transition to the concrete operational stage and adapt to learning

at primary school. However, introducing calculus instruction among primary school students deviates significantly from children expected cognitive development trajectory. The prolonged exposure to such educational practices may not align with the child's developmental patterns and could harm the child's overall development.

The state's "Double-Reduction" policy has shown positive results in significantly striking the phenomena of acceleration mathematics during the primary period, reducing occurrences of students learning calculus over the past three years [4]. However, some traditional institutions and parents still advocate accelerating children's mathematics learning. It reminds educators and parents of the need to raise awareness about the potential negative impact of accelerated mathematics education on children's development.

When seeking theoretical support, it has been observed that although there is a substantial body of literature on primary school mathematics, the predominant focus lies within two significant areas: primary school mathematics teaching and the primary school mathematics classroom. By contrast, there is a research gap on the effects of acceleration in mathematics on child development during the primary period. Therefore, given the current social context of acceleration in mathematics during the primary period, investigating the influence of acceleration in mathematics on children's development is very significant. It facilitates aligning compulsory mathematical instruction with children's developmental patterns and effectively harnesses mathematics educational function. Furthermore, it can provide essential theoretical underpinnings for formulating relevant policies at a national governmental level. Based on existing literature, this study will delve into three key aspects: rational thinking, scientific mindset, and personal intelligence development to explore the challenges posed by the acceleration in mathematics during the primary period on children's development while proposing effective solutions and drawing pertinent conclusions. Ultimately, this study offers constructive guidance for mathematics education during the prior period.

2. Analysis of the Problems

2.1. Rational Thinking

Clear and distinct directionality characterizes the rational thinking dimension, which provides a cognitive framework for observing, comparing, analyzing, synthesizing, extracting, and summarizing phenomena or inquiries [5]. Rational thinking is essential in achieving the educational objectives of primary school mathematics. However, accelerated mathematics education during the primary period may hinder the development of rational thinking.

According to the investigation, although the Ministry of Education of the People's Republic of China has explicitly banned the inclusion of Olympic math in the evaluation system for primary schools to junior high schools, the increasing number of extended questions in the entrance exam in some junior high schools has led to students having to learn advanced topics such as binary equations, permutations, and combinations, which should be taught in higher education [6]. As a result, the focus of the Mathematical Olympiad has shifted from stimulating students' interest and fostering their rational thinking skills to preparing them for the complex math of high school at an earlier age. Meanwhile, there is a growing trend of people learning the mathematics Olympiad, but not all students are interested or suitable for studying it [6]. The original mathematical foundation of these children needs to be stronger, and the complexity and abstractness of Olympic math problems often pose a significant challenge. A substantial disparity in problem-solving methods, thinking approaches, and blind expansion without mastering the fundamental knowledge can cause many children to lose a clear direction in solving math problems, impeding rational thinking development.

Also, due to varying quality standards among Olympic math classes offered today, some institutions teach advanced concepts from junior high and high school math curricula to attract customers. Moreover, throughout primary education, students gradually develop abstract rational thinking while maintaining concrete thinking. Compared with it, the mathematical knowledge taught in junior and senior high schools predominantly relies on symbolic representation, conceptual

understanding, reasoning abilities, and other higher-order skills that pose considerable challenges for primary school students who primarily think in concrete images. Acceleration in mathematics may even hinder the formation of children's abstract thinking [6]. Furthermore, these educational institutions prioritize content-focused instruction through classroom lessons, their primary instructional approach, rather than fully engaging students. As children progress through primary school, they tend to rely less on their experiences to learn new things. This shift can cause a decline in their ability to ask questions and gain insights about the world around them. As a result, they may struggle to make generalizations and understand the essence of what they are learning, which can hinder the development of their ability to think critically and rationally.

To summarize, acceleration in mathematics goes against the principles of children's cognitive development and hinders the development of their abstract and rational thinking.

2.2. Scientific Spirit

The scientific spirit is crucial for science to fulfill its social and cultural functions. It involves the pursuit of truth through empirical evidence and a commitment to pragmatism and innovation. In the context of primary school mathematics, the scientific spirit combines subject characteristics and fundamental principles, emphasizing systematic thinking, logical rigor, and practical application [7]. Culturing the scientific spirit should be tailored to match the cognitive development stage of primary school students and gradually integrated into the mathematics classroom. However, the current trend of accelerating primary school mathematics can significantly hinder the fostering of children's scientific spirit.

According to the philosopher Rousseau, children are meant to experience childhood before transitioning into adulthood. Disrupting this natural order leads to premature outcomes that are not fully developed or advantageous. It is like producing mature children and young doctors at the same time [8]. Nowadays, children receive accelerated learning in mathematics, allowing them to acquire knowledge and skills early. However, their cognitive abilities need to be improved to support comprehensive thinking about what they learn. Accelerated learning still leaves their learning style mostly receptive rather than engaging in questioning processes [6]. It harms cultivating the spirit of inquiry necessary for scientific curiosity and development.

Meanwhile, as relevant literature mentioned, questioning arises when there are contradictions between theory and practice [9]. Playtime in childhood is an essential form of children's practice, which helps children systematize their knowledge base and effectively apply acquired information [10]. Unfortunately, in accelerated education, there is an excessive emphasis on acquiring knowledge, often at the expense of children's playtime, which plays a crucial role in fostering the scientific spirit. The lack of Children's playtime leads to difficulties in applying what they learn in real-life situations, which hinders the development of their questioning spirit. This questioning spirit is essential for nurturing scientific curiosity, and its absence impedes learning and development within their scientific mindset.

2.3. Intellectual Development

Intelligence refers to an individual's ability to acquire, apply, and generate knowledge and their capacity to investigate, analyze, and solve problems. It is crucial to focus on students' cognitive development, not only for the progress and advancement of society but also for enhancing the overall quality of math education at the compulsory level. The research findings, however, indicate that acceleration in mathematics education may not only fail to enhance children's intellectual development but also impede their average cognitive growth.

Vygotsky's theory of the "zone of proximal development" emphasizes the importance of designing and adapting instructional materials to meet the specific needs of students [11]. This theory recognizes that student development levels are dynamic and subject to change. Good teaching should occur during the "optimal period," between the lowest limit of effective teaching and the highest potential level determined by their zone of proximal development. Teaching beyond this zone would be

ineffective or challenging for students, while lowering instruction to match their current level would be repetitive and unengaging. Therefore, only instruction tailored to their nearest developmental area proves effective and beneficial.

An American psychologist, Gesell, conducted the twin ladder experiment to show how maturation affects individual development. The experiment suggested that education should be aligned with a child's actual level and not interfere with their natural developmental "timetable." [12] For instance, a mother from an urban area spent over 100,000 yuan in five years to enroll her child in seventeen training courses. As a result, the child completed the second-grade curriculum by age five but was only allowed half a day off per week and had to return home daily at nine o'clock for further studies. Initially, the child excelled as a first-grader and found the teacher's instruction easy to understand. However, as the child moved to second grade, their academic performance began to deteriorate, transitioning from being among the top students to becoming average, and they gradually developed an aversion towards learning. The child also neglected their homework and was easily distracted in class [12]. This example shows that accelerated learning may be suitable for intellectually gifted children but can prove counterproductive for ordinary children by putting undue pressure on them, which can be detrimental to their long-term intellectual growth.

3. Suggestions

The acceleration in mathematics during the primary period has brought about pressing issues, necessitating an urgent curriculum reform. In the subsequent section, researchers will conduct a comprehensive investigation into three branches of curriculum reform: namely, the reform of teaching content, innovation of teaching methods, and interdisciplinary evaluation standards. The aim is to propose practical solutions.

3.1. Innovation of Teaching Methods

According to the analysis above, one of the most prominent and pressing issues in mathematics instruction during the primary period is the lack of student participation. This phenomenon persists in conventional classrooms and extends to accelerated education settings. However, numerous students engage in extracurricular accelerated learning due to their enduring belief that this occurrence within conventional classrooms hinders them from attaining a satisfactory classroom experience and acquiring in-depth knowledge comprehension. Consequently, they pursue accelerated learning to obtain an enhanced classroom experience or a more profound understanding of knowledge.

Thus, enhancing students' active participation in class, fostering a proper learning mindset, enabling them to recognize the inherent significance of acquiring mathematical knowledge autonomously, and applying it practically is imperative. This matter transcends mere contemplation by teachers; meanwhile, it has evolved into one of the foremost concerns within contemporary education.

Mathematics education in primary school should not be limited to simply imparting knowledge, nor should it rely solely on passive acceptance and memorization. Instead, it should encourage active learning through children's perceptual experiences of their environment. Children should be motivated to engage in practical manipulation and exploration, interact with specific situations in their lives, utilize their existing experiences for discussion and communication, collaborate to solve real-world problems and employ mathematical thinking to inquire and fulfill the role of mathematics as an instrumental discipline.

In terms of teaching methods, teachers need to move away from one-way knowledge dissemination and instead focus on fostering deep engagement between students and teachers during classroom instruction. They should strive to create a classroom atmosphere that encourages students to question freely, express their ideas confidently during class discussions, and actively participate in constructing mathematical concepts. It will help cultivate scientific spirit and rational thinking among students throughout the learning process. At the same time, teachers can dynamically assess the level

of student participation during class sessions to adjust teaching content based on individual aptitude. By accurately identifying each student's latest developmental stage within the mathematics education domain at any given time, they can effectively promote intellectual growth.

Moreover, different students may encounter diverse challenges during their practice processes, which enables teachers to provide targeted guidance and instruction tailored to each student's needs. It can promote personalized student development and contribute to the school's overall advancement.

To sum up, to cultivate versatile and multifaceted talents, teachers can grant students more autonomy in instructional methods, allowing them to foster rational thinking and a scientific mindset through personal exploration, thereby facilitating intellectual growth.

3.2. Improve Teaching Content

Improving the teaching content is as essential as innovating the teaching methods. The government can start by adjusting the balance between practical and purely theoretical courses in primary school mathematics education to improve the teaching content. It can transform specific theoretical courses, such as "Mathematics Wide Angle," into flexible ones that integrate practical content with theoretical instruction or fully develop practical courses. Increasing the proportion of practical courses and promoting interdisciplinary connections with real-world applications can also address the issue where some schools prioritize accelerated learning at the expense of children's experiential education while fostering their rational thinking ability and scientific spirit.

In addition, when selecting teaching materials and content, the government must consider students' cognitive patterns and developmental stages. Using gamification techniques to present textbook exercises can effectively engage students and promote intellectual development. It is necessary to approach the issue from two perspectives for primary school children in economically developed areas who are accelerated learning subjects like calculus. If these children display exceptional intellectual abilities, the country can introduce a new educational platform that provides high-quality instructional videos to meet their learning needs while preventing them from participating in extracurricular courses of varying quality.

However, it is essential to note that pursuing such courses should not be driven by unreasonable parental expectations. In such cases, the state should reinforce the implementation of "Double-Reduction" policies aimed at reducing academic burdens and regulate after-school tutoring classes more strictly to prevent a resurgence of excessive academic pressure.

3.3. Evaluation Criteria for Interdisciplinary Education

Currently, the country is promoting the integration of "teaching evaluation." Therefore, to improve teaching methods and content, it is essential to diversify assessment formats. In the past, the teaching evaluation system primarily relied on simple tests where teachers assessed students' learning through theoretical knowledge questions. However, this approach needs to be revised as an evaluation method. Apart from focusing solely on the quality and significance of theoretical courses, how questions are formulated makes it challenging to provide comprehensive feedback on student learning. Sometimes, the emphasis of assessment shifts from knowledge to understanding the question structure. Sometimes, students who have mastered the examination subjects may not receive points due to deficiencies in reviewing and answering skills. This situation is absurd and results in better-knowledgeable students not necessarily achieving higher grades.

The Ministry of Education should update the current test-centric form of assessment, which solely relies on scores, by prioritizing process-oriented aspects such as collaborative activities to enhance evaluation effectiveness. As assessment methods become more diverse, parents may shift their focus from emphasizing accelerated academic learning to fostering a well-rounded child through moral, intellectual, physical, and professional development efforts. However, practical implementation poses numerous challenges. For instance, using diversified evaluation methods may introduce subjectivity in score weighting, which differs significantly from the objective right-or-wrong scoring system used previously. It amplifies the complexity of evaluation, requiring continuous development

and gradual reforms to optimize teaching evaluation standards and grading systems. The government can collaborate with educational experts to establish rational evaluation criteria for mathematical exploration processes while integrating math assessment with other disciplines to ensure objectivity for public scrutiny.

4. Conclusion

Studies have shown that the acceleration in mathematics education during the primary period can cause a deviation from the typical cognitive development pattern observed in most children. Accelerated mathematics education poses several challenges, including inconsistent teaching quality, limited availability of playtime, and teaching materials that do not align with students' cognitive abilities. These challenges can negatively impact students' rational thinking skills, capacity to develop a scientific spirit and overall intellectual development.

Mathematics is essential in primary education to develop children's number sense, logical reasoning, and spatial imagination. It even affects their outlook on life, worldview, and values formation. The study analyzed the impact of acceleration in mathematics education on primary school children's rational thinking, scientific spirit, and intellectual development. The researchers combined relevant data with thorough analysis to provide targeted guidance and specific operational references for addressing this phenomenon. The primary objective of this research was to improve the educational function of mathematics education and provide help for children's healthy growth. Moreover, it also addresses the academic gap regarding the effects of accelerated mathematics education on the development of children during the primary period. The researchers provided theoretical backing in line with modern educational theories for the current advancements in Chinese education.

However, the study focuses solely on the impact of accelerated mathematics education on three specific aspects of a child's development: rational thinking, scientific spirit cultivation, and intellectual development. It is essential to note that the study did not examine other potential impacts of accelerated mathematics education on child development during different stages. Future research can explore how accelerated mathematics education may influence a child's development, such as language expressions, social skills, emotional intelligence, number sense and creativity. Such research can provide a more comprehensive understanding of accelerated mathematics education's potential benefits and drawbacks and inform educational policy and practice.

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