Open Access Library Journal
2025, Volume 12, e14434
ISSN Online: 2333-9721
ISSN Print: 2333-9705

The Opportunities and Challenges of Declining Birthrates for Small-Class Science Teaching in Secondary Schools

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How to cite this paper: Hu, X.Y. (2025) The Opportunities and Challenges of Declining Birthrates for Small-Class Science Teaching in Secondary Schools. *Open Access Library Journal*, **12**: e14434.
https://doi.org/10.4236/oalib.1114434

Received: October 12, 2025
Accepted: November 1, 2025
Published: November 4, 2025

Abstract

Amidst China's declining birthrates, junior high science education is shifting from scale expansion to quality enhancement, with small-class teaching being a key strategy. This multi-method study reveals that smaller classes promote interactive, inquiry-based learning, boosting student engagement, innovation, and critical thinking. Success depends on teachers transitioning from knowledge transmitters to learning facilitators, requiring training in differentiated instruction and educational technology. Policy support—optimized teacher allocation and reformed evaluation systems—is essential for effective implementation. The study offers strategic insights for adapting basic education to demographic change.

Subject Areas

Pedagogy

Keywords

Fewer Births, Science Education, Small-Class Teaching, Teacher Role, Education Policy

1. Introduction

As China's demographic structure undergoes a profound transition, declining birthrates have become a significant trend impacting socio-economic development. According to data from the National Bureau of Statistics, the national population decreased by 2.08 million year-on-year by the end of 2023, with a natural growth rate of −1.48‰. Moreover, the total fertility rate of women of childbearing age in 2020 was only 1.3, remaining at a relatively low level. This demographic shift has had a profound and direct impact on the education system, particularly creating an urgent need to reduce class sizes in primary and secondary schools and optimize the allocation of educational resources. Currently, the standard class size in Chinese junior high schools is 50 students, significantly higher than the OECD average of 23, highlighting a structural contradiction between the current scale of education and its quality. Against this backdrop, the Compulsory Education Science Curriculum Standards emphasize an innovation-oriented approach, focus on addressing students' individualized and diverse learning needs, and enhance the suitability and contemporaneity of the curriculum, providing clear policy justification and practical impetus for the implementation of small-class teaching.

Confronted with the practical contradiction between scale and quality, alongside policy-driven reform directions, promoting small-class teaching has become a critical initiative. Both domestic and international research has extensively explored and practiced the value of small-class teaching. Internationally, countries such as Finland have significantly enhanced education quality through small-class teaching models, with their students demonstrating outstanding performance in the Programme for International Student Assessment (PISA), empirically validating the advantages of small-class teaching in promoting personalized learning and inquiry-based practices. Domestically, regions like Hangzhou, Zhejiang Province, have pioneered small-class teaching trials. By reducing class sizes and optimizing teacher-student ratios, they have effectively improved teaching outcomes and student engagement, providing valuable localized practical experiences for the reform of small-class science education in junior high schools in China. However, despite abundant research, existing studies predominantly focus on macro-level policies or general teaching strategies. There remains a notable lack of systematic research on small-class science teaching in junior high schools within the specific context of declining birthrates, particularly an in-depth analysis of the unique challenges and developmental opportunities faced in this subject area.

Therefore, to address this research gap, this study aims to systematically explore the opportunities and challenges of small-class science teaching in junior high schools against the backdrop of declining birthrates. It will focus on how to enhance the quality of science education by effectively utilizing the small-class environment through curriculum content updates, teaching method innovations, and teacher professional development. The specific research questions include: First, how can a more interactive and inquiry-based science teaching model be constructed in small-class settings? Second, what professional competencies do teachers need to adapt to the demands of small-class teaching? Third, how can education policies support the effective implementation of small-class teaching? By investigating these questions, this study aims to provide empirical evidence and strategic recommendations for the reform of basic education in China, addressing the long-term educational challenges posed by demographic changes.

2. Literature Review

2.1. Current Status of Research on Small-Class Teaching Abroad

Internationally, Small-Class Teaching is widely regarded as an effective strategy for enhancing education quality. The practices in Nordic countries, particularly Finland, serve as exemplary models. The Finnish education system is renowned for its small class sizes, highly qualified teaching force, and highly autonomous curriculum. The average class size at the junior high school level in Finland is maintained below 20 students. This model aligns with a foundational principle of its system: a culture of trust where, as Wang (2013) notes, there is a "conscious professional responsibility based on trust" and an absence of strict international accountability models [1]. This environment provides a solid foundation for teachers to focus on individual differences and implement inquiry-based teaching, which is considered one of the key factors contributing to the consistently outstanding performance of Finnish students in the Programme for International Student Assessment (PISA). Research indicates that small-class environments significantly increase the frequency of teacher-student interactions, enable personalized instruction, and effectively promote the development of students' social-emotional skills. The "STAR" project (Student/Teacher Achievement Ratio) conducted in Tennessee, USA, as a classic randomized experimental study, provides strong empirical evidence supporting the long-term positive impact of small-class teaching (especially in lower grades) on students' academic achievement. These international experiences collectively demonstrate that small-class teaching is not merely about reducing class size but represents an important pathway toward high-quality, personalized education.

2.2. Exploration and Practice of Small-Class Teaching in China

Domestically, in response to the changes in student demographics resulting from declining birthrates, some regions have taken the lead in exploring and practicing small-class teaching. Zhejiang Province, particularly Hangzhou, is a pioneer in this regard. Hangzhou has implemented small-class teaching reforms in some primary and secondary schools, intentionally controlling class sizes (typically reducing them to below 35 students) to optimize the educational ecology and enhance teaching effectiveness. Practice has shown that the small-class environment creates favorable conditions for conducting experimental inquiry, group collaboration, and project-based learning in science courses, significantly increasing student classroom participation and satisfaction [2]. This model is also being explored in higher education for cultivating innovative talents in specialized fields like veterinary medicine, where its emphasis on practical skills and close interaction aligns well with disciplinary needs. These localized practices have accumulated valuable experience for promoting small-class teaching in China, demonstrating its potential to stimulate students' learning interest and foster innovative. However, current explorations are mostly concentrated in economically developed cities, and how to adapt and promote these experiences nationwide, especially in different subjects (such as science education), requires further research.

2.3. Research Review

In summary, both domestic and international studies affirm the value of small-class teaching in promoting personalized learning and enhancing education quality. International research provides rich theoretical support and rigorous empirical evidence, while domestic practices have explored localized implementation pathways. However, existing research still has the following shortcomings: First, most studies focus on macro-level policies or general teaching models, with a noticeable lack of systematic research targeting the specific subject of "junior high school science." Science education places higher demands on experimental inquiry, hands-on practice, and critical thinking, and how small-class teaching can unleash greater efficacy in this field urgently requires in-depth analysis. Second, existing research fails to fully embed the specific socio-demographic context of "declining birthrates" into the discussion, lacking an analytical framework that treats demographic change as a core variable. Therefore, this study aims to fill these research gaps by systematically exploring the unique opportunities, challenges, and implementation pathways of small-class science teaching in junior high schools against the backdrop of declining birthrates, providing subject-specific and contextually strategic references for the reform of basic education in China.

3. Research Design and Methodology

3.1. Research Approach and Framework

This study follows an overall approach of "theoretical construction-current situation analysis-proposal of solutions." First, a theoretical foundation is established through literature research. Second, survey and comparative methods are employed to analyze the current implementation status and challenges of small-class teaching in junior high school science education. Finally, based on empirical findings, systematic response strategies are proposed. The research framework revolves around the core logic of "Opportunities-Challenges-Pathways," aiming to address how to optimize junior high school science education through small-class teaching in the context of declining birthrates.

3.2. Research Methods

To ensure the scientific rigor and comprehensiveness of the study, a mixed-methods research approach is adopted, integrating the following methods:

Literature Analysis: Systematically review domestic and international research on declining birthrates, small-class teaching, and science education to provide theoretical support for the study.

Survey Research: Utilize questionnaires and interviews to collect first-hand data on the perceptions, needs, and implementation effects of small-class teaching from junior high school science teachers, students, and parents.

Comparative Analysis: Compare and analyze the strategies and effectiveness of implementing small-class science teaching across different regions and schools to identify effective models.

Case Study: Conduct in-depth research on existing practical cases domestically (e.g., in Zhejiang Province) to summarize successful experiences and common challenges.

3.3. Research Process and Implementation

The research process will be carried out in phases:

- Phase 1 (Months 1 - 2): Literature review and theoretical framework construction.
- Phase 2 (Months 3 - 4): Design survey instruments and conduct on-site surveys and interviews in six junior high schools across Hangzhou, Ningbo, and Jinhua cities in Zhejiang Province. The survey sample includes 85 science teachers, 420 eighth-grade students, and some parents to understand the perceptions of different groups regarding small-class teaching.
- Phase 3 (Months 5 - 6): Integrate and analyze all data and materials, with quantitative data and qualitative interview content being cross-analyzed using the triangulation method to ensure the credibility of the research findings.
- Phase 4 (Months 7 - 8): Integrate and analyze all data and materials.
- Phase 5 (Months 9 - 10): Draft the research report, present conclusions, and propose countermeasures.

4. Findings

Preliminary analysis of questionnaire data and interview materials revealed the following findings:

In terms of perceptions among teachers and students: Over 80% of the surveyed teachers believed that reduced class sizes significantly increase the frequency of teacher-student interactions. However, approximately 65% of teachers reported a lack of systematic training in inquiry-based teaching methods tailored for small-class settings. More than 75% of students indicated a noticeable increase in both willingness and opportunities to participate in science experiments and group discussions within the small-class environment.

Regarding resources and implementation: Case schools generally reported that the current quantity and renewal rate of laboratory equipment are insufficient to fully meet the demands of group experiments in small classes. Furthermore, classroom layouts require adjustments to accommodate teaching models such as Project-Based Learning (PBL).

Regional disparities: Schools in economically developed regions demonstrated stronger capabilities in mobilizing resources when implementing small-class teaching reforms. In contrast, schools with relatively limited resources faced greater challenges.

5. Analysis of Opportunities

Firstly, it significantly enhances the quality of teacher-student interactions. Teachers are freed from extensive classroom management responsibilities, allowing them to devote more attention to observing and guiding each student's learning process. This shift is further empowered by educational technology. At present, artificial intelligence is mainly used in the field of education for personalized learning and assessment of student progress and has achieved certain results [3], which are reflected in its ability to provide immediate and detailed feedback. In science classes, teachers, aided by such tools, can engage closely with each group, providing guidance on students' operational techniques, data recording, and conclusion drawing. This effectively addresses the common issue in large-class settings where "students observe while the teacher demonstrates," thereby making inquiry-based learning truly feasible.

Secondly, small class sizes ensure both the safety and depth of experimental teaching. Subjects such as physics, chemistry, and biology require extensive hands-on practice. The small-class environment allows for the safe conduct of high-risk and high-cost experiments, while significantly increasing each student's opportunities for practical operation. This is essential for cultivating their scientific practical abilities.

Finally, small-class teaching creates ideal conditions for implementing Project-Based Learning (PBL). Students can engage in deeper group collaboration and sustained inquiry around real-world topics such as "campus ecological surveys" or "low-carbon solution design." The role of the teacher shifts from a lecturer to a coach and resource coordinator, better fostering students' innovative thinking and ability to solve real-world problems.

6. Analysis of Challenges

6.1. Research Approach and Framework

While opportunities exist, they are accompanied by significant challenges, most notably a structural contradiction in the teaching workforce featuring an overall surplus alongside regional and subject-specific shortages. This issue is compounded by many teachers' lack of training in inquiry-based methods for small-class settings, highlighting an urgent need for professional development. Secondly, there is insufficient support in teaching resources. Current classroom layouts, the quantity of laboratory equipment, and the pace of updates fall short of meeting the demands of small-class group teaching. This resource gap hinders the effective implementation of differentiated and hands-on instructional strategies.

Finally, there is a risk to educational equity. Without coordinated planning and policy support, reforms could exacerbate disparities between schools. Well-resourced schools may quickly benefit from small-class teaching, while underfunded ones might end up with "small classes but low quality," ultimately failing to provide equitable educational opportunities.

6.2. Systematic Implementation Pathways

Pathway 1: Innovate Teacher Allocation and Training Mechanisms

Optimize teacher allocation through a "county-managed, school-appointed" system and refocus training on essential small-class science strategies, including differentiated task design, PBL project development, and formative assessment methods.

Pathway 2: Enhance Resource Supply and Technological Empowerment

Educational investment should prioritize the renovation of classroom spaces and the upgrading of laboratory equipment. Additionally, actively integrate digital resources—such as the National Smart Education Platform for Primary and Secondary Schools and virtual experiment libraries—to compensate for shortages in physical resources and support teachers in learning analytics and personalized student guidance.

Pathway 3: Improve Policies and Evaluation Frameworks

Develop specialized policies for small-class teaching that clearly define standards for class size, teacher qualifications, and funding. Reform the educational fund allocation mechanism by exploring per-class subsidies to incentivize schools to adopt small-class models. Incorporate teaching process quality and holistic student development into school evaluation systems to steer schools toward connotative development.

7. Conclusions and Prospects

7.1. Main Research Findings

This study demonstrates that although declining birthrates pose challenges, they also present a historic opportunity for the advanced transformation of junior high school science education. Small-class teaching serves as a critical vehicle for achieving refined and inquiry-based science education, effectively enhancing the quality of teacher-student interactions, ensuring depth in experimental learning, and promoting project-based learning. However, its successful implementation heavily depends on teacher competencies, resource allocation, and systematic policy support.

7.2. Policy and Practical Implication

It is recommended that educational authorities issue targeted guidelines for small-class teaching, accompanied by supporting policies on teacher staffing, funding guarantees, and supervision mechanisms. At the school level, efforts should focus on building professional learning communities for teachers, reforming classroom teaching models, and leveraging information technology to empower instructional practices.

7.3. Research Limitations and Future Directions

While this study is primarily based on literature and macro-level analysis, future research could employ in-depth case comparisons and empirical investigations to quantitatively analyze the impact of small-class teaching on students' scientific literacy across different regions and demographic groups. Long-term tracking of its effects will provide a more precise evidence base for policy adjustments.

Conflicts of Interest

The author declares no conflicts of interest.

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