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A Study on the Integration of the History of Mathematics into University Mathematics Courses

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Abstract: This paper discusses the necessity of integrating the history of mathematics into university mathematics courses from three aspects: using mathematical history as a teaching tool, expanding it in course materials, and incorporating it as an element of ideological and political education. It also identifies the issues related to the integration of mathematical history into university mathematics courses, including insufficient inclusion of mathematical history content during classroom teaching, limited representation of mathematical history content in textbooks, and insufficient depth and breadth when integrating mathematical history as an element of ideological and political education. Based on these issues, the paper provides strategies for incorporating mathematical history into university mathematics courses, including integrating mathematical history content appropriately during classroom teaching, increasing the inclusion of mathematical history content in textbook development, and enhancing the depth and breadth of integration when used as an element of ideological and political education.

1. Introduction

University mathematics encompasses various courses, and for students majoring in mathematics, almost all of their courses are mathematics-related, such as mathematical analysis, advanced algebra, analytic geometry, real analysis, complex analysis, modern algebra, and more. Even for students in science and engineering majors, they will study courses like advanced mathematics, linear algebra, probability and statistics, and some may even take discrete mathematics. Some liberal arts majors might also include courses like calculus. The common feature of all these mathematics courses is their abstract nature and theoretical emphasis, making them appear dry and challenging to most students. How to effectively teach these courses has been a persistent question for many university instructors. Early science historian Cajori believed that knowledge of the history of science can enhance students' interest in learning and enable teachers to better understand students' learning difficulties, thus assisting students in their studies. He described knowledge of the history of a subject as "the honey that makes bread and butter more palatable" and stated that it adds attractiveness to the subject.[1] This holds even truer for mathematics, a subject known for its abstract and highly theoretical nature.

Currently, the study of the relationship between the history of mathematics and mathematics education (HPM) is an important component of mathematics education research and plays a crucial role in today's mathematics classrooms.[2] Since the establishment of international HPM, significant progress has been made in both theoretical and practical research through continuous in-depth investigation and development. HPM research has shifted from early experience-based summaries and theoretical discussions to practical research on the integration of mathematical history into the classroom.[3] In terms of research on the integration of mathematical history into mathematics courses in China, most studies have focused on primary and secondary school courses, with relatively fewer studies on integrating mathematical history into university mathematics courses. However, university mathematics is even more abstract and theoretical, making the integration of mathematical history into university mathematics courses all the more necessary.

2. Necessity of Incorporating the History of Mathematics into University Mathematics Courses

2.1. As a Teaching Tool

University-level mathematics courses are highly abstract and theoretical. If students learn only the subject matter without understanding why they are studying it or its historical development and future applications, the learning process can be dry and challenging. A survey conducted by Duan Luling [4] among first-year mathematics education students at her institution revealed that a high proportion, up to 65.9%, did not like mathematics, while only 9.2% of students found mathematics very interesting. Enhancing students' enthusiasm for learning and helping them find motivation for learning is an ongoing concern for many university mathematics educators. Jankvist pointed out that the history of mathematics, when used as a supplementary teaching tool, can help students appreciate and develop a passion for mathematics, all while deepening their understanding of the subject [5]. This is because the history of mathematics, as a teaching tool, can motivate students to learn, reinforce their mathematical cognition, and naturally contribute to the development of mathematical concepts.

2.2. As a Curriculum Extension

Textbooks serve as essential carriers of course content, playing a crucial role in achieving educational goals and enhancing the quality of education and talent development [10]. Most university mathematics textbooks consist of two main sections: knowledge content and exercises. Both sections typically lack substantial content related to the history of mathematics or the historical context of the covered topics. The teaching content has remained largely unchanged since the 1950s and 1960s, which means that essential foundational mathematics content for contemporary science and technology often goes unaddressed in the classroom. Textbooks emphasize comprehensiveness and rigor, resulting in a tendency toward theoretical and abstract presentations [6]. If we incorporate historical context or practical applications of relevant mathematical concepts into textbooks during their development, students will have a clear understanding of the purpose behind learning these concepts. Engaging textbooks not only benefit student learning but also greatly assist teachers in lesson preparation, making their classes more appealing.

2.3. As an Element of Ideological and Political Education

To implement General Secretary important educational discourse and the spirit of the National Education Conference, and to deepen the reform and innovation of ideological and political education in colleges and universities, the Ministry of Education issued the "Guidelines for the Construction of Ideological and Political Education in Higher Education Courses" in May 2020 [7]. These guidelines emphasize the integration of ideological and political education into the entire system of talent cultivation in higher education and the comprehensive promotion of course-based ideological and political education, aiming to enhance the quality of talent development. Curriculum-based ideological and political education is a comprehensive approach to integrating various elements of ideological and political education into all aspects and aspects of higher education teaching and education, with the goal of fostering moral integrity in students and establishing a well-rounded system of ideological and political education courses [8]. The inclusion of the history of mathematics as one of the elements of curriculum-based ideological and political education can cultivate students' behavioral qualities of loving learning and critical thinking, instill in them the right values, and promote noble spiritual pursuits. The incorporation of mathematical history can help students gain a more objective understanding of mathematical knowledge and encourage them to contemplate the development of mathematical concepts, mathematical thought, and mathematical methods from a historical perspective [9]. Many mathematicians possess excellent qualities and a resilient spirit. By introducing students to these mathematicians, we can nurture scientific spirit and character traits such as seeking the truth, being unafraid of difficulties, and inculcate values of integrity, making it highly valuable for character development.

3. Problems with Incorporating the History of Mathematics into University Mathematics Courses

3.1. Insufficient Incorporation of Mathematical History Content in Classroom Teaching

Currently, most university mathematics courses inadequately integrate the history of mathematics into classroom teaching. One of the reasons for this is that university mathematics courses typically have extensive content but limited class hours. Consequently, many instructors focus solely on delivering core knowledge points, without sufficient time to delve into the historical development of these concepts. A review of mathematics courses offered by various universities through platforms such as Chinese University MOOC and iCourse reveals that most instructors primarily cover knowledge points. Interestingly, most students are genuinely interested in the history of mathematics. Therefore, instructors often use mathematical history as an introduction to stimulate student interest and create an engaging classroom atmosphere. However, when considering the entirety of a lesson, the amount of mathematical history incorporated is relatively minimal. Rather than being limited to introductions, mathematical history should be more extensively integrated, especially when teaching theorems, definitions, and mathematical methods, which, if connected to mathematical history, can significantly deepen students' understanding of the subject matter, rather than simply passing over it.

Another reason is that some instructors have limited knowledge of mathematical history. Investigations have shown that the level of mathematical history literacy among university mathematics instructors varies. Some instructors believe that integrating mathematical history elements into teaching is not very meaningful, and as a result, they rarely incorporate mathematical history into their lectures. In some cases, instructors themselves are not very familiar with mathematical history content, which makes it challenging for them to include it in their teaching. Many instructors recognize the importance and educational value of mathematical history in mathematics courses but are unable to put it into practice due to their limited knowledge. The educational value of mathematical history is undeniable, but the challenge lies in finding effective ways to incorporate it into university mathematics classrooms.

3.2. Limited Representation of Mathematical History Content in Textbooks

Traditional mathematics teaching and textbook development place excessive emphasis on knowledge transfer, often neglecting the cultivation of values, abilities, and a scientific spirit [10]. Across university mathematics textbooks in China and abroad, the inclusion of the history of mathematics is quite limited, particularly regarding the history of each individual mathematical concept. Some textbooks provide brief introductions to mathematicians at the end of each chapter, explaining the context in which certain knowledge points arose. However, such content remains relatively scarce. For example, the creation of calculus, which is fundamental for students in various science and engineering disciplines, was developed by Newton and Leibniz as a response to the needs of the First Industrial Revolution, inspired by ancient Greek concepts such as the "method of exhaustion" and the computation of areas under parabolic arcs. The traditional deductive system of Euclidean geometry alone could not have led to the development of calculus. In the early stages of its development, the definition of "infinitesimal" was somewhat ambiguous, and it took several decades for mathematicians to refine it through continuous supplementation and improvement. Without a clear understanding of the historical context of concepts like infinitesimals, differentiation, and integration, students' comprehension of these knowledge points may lack depth. Education is evolving with changing times, so teaching and textbooks should also develop alongside, which emphasizes the importance of incorporating the history of mathematics into course materials.

3.3. Lack of Depth and Breadth in Incorporating Mathematical

History as an Ideological and Political Education Element The history of mathematics is often integrated into classroom teaching as part of ideological and political education, and many university mathematics instructors do this. However, there are several issues with its integration into classroom teaching:

First, some instructors provide only a simple presentation of historical facts related to mathematics, sometimes even offering anecdotes about mathematical figures without relying on proper historical sources.

Second, some instructors focus only on Chinese mathematical achievements and neglect the contributions of international mathematicians. This one-sided approach can lead to a limited and biased understanding of mathematical history among students.

Third, when instructors introduce mathematical history, they often provide basic information about mathematicians, their years of birth and death, and their contributions, but they do not sufficiently explain the connections between this history and the relevant knowledge points. This presentation can come across as rigid and mechanical.

Fourth, some instructors tend to exaggerate stories about certain mathematicians, even if these stories lack credibility, in an attempt to capture students' attention. Instructors should focus on using mathematical history to reveal related mathematical content, create a mathematical cultural atmosphere, and establish close connections with students' cognitive patterns, thereby facilitating a deeper understanding of mathematical content [11].

4. Strategies for Incorporating the History of Mathematics into University Mathematics Courses

4.1. Appropriately Integrating Mathematical History into University Mathematics Classroom Teaching

For many universities, mathematics courses face the challenge of having extensive content but limited class hours. To address this issue, various teaching methods can be employed. One effective approach is to assign group tasks in advance, requiring students to collect valuable historical mathematics materials through online resources or libraries. These materials can then be discussed and interpreted in the classroom, saving precious time for incorporating mathematical history. In this way, students become actively engaged in gathering materials, and during the classroom discussions, any gaps or inaccuracies in their findings can be corrected. Furthermore, students gain preliminary knowledge about the subject matter before collecting materials, leading to a deeper understanding of the content when they explore relevant historical mathematics materials. This approach not only makes classroom teaching more efficient but also enhances students' comprehension of the course content.

To address the issue of instructors' insufficient knowledge in mathematical history, teachers can take several steps. Firstly, instructors can enhance their own knowledge base by reading books or materials related to mathematical history. Continuous self-improvement is essential for teachers in this regard. Secondly, instructors can participate in training programs related to mathematical history. These training programs can be both online and offline. Given that instructors often have busy teaching schedules during regular semesters, such training may require the strong support of their institutions. Therefore, universities should organize specific training programs for integrating mathematical history into teaching, allowing mathematics educators to explore effective ways to do so from both professional and practical perspectives. These training programs can be conducted through centralized and decentralized approaches. Centralized training sessions can be held during holidays, with the participation of all instructors. Given teaching workloads, decentralized training allows individual instructors to attend, and upon returning to their institutions, they can share their training experiences with other teachers to collectively enhance their teaching abilities for the benefit of students.

4.2. Enhancing the Inclusion of Mathematical History in University Mathematics Textbook Development

Taking the example of mathematical analysis, which is a primary course for university mathematics majors and shares much of its content with courses such as advanced calculus, it is evident that mathematics educators should draw inspiration from renowned scientists such as Pascal, Kepler, Galileo, and Newton by examining their works throughout history. This perspective can lead to the creation of more student-centered and humanized mathematical analysis textbooks. Klein, a mathematician, believed that authors of mathematical analysis textbooks should read works of great scientists like Pascal, Kepler, Galileo, and Newton from the past to make their textbooks more user-friendly. He criticized textbooks that only emphasized strict logic, asserting that "mathematics does not consist of deducing unquestionable conclusions from explicitly stated axioms." Poly á strongly agreed with Klein, arguing that only by understanding how humans gained knowledge of certain facts or concepts can we make better judgments about how students should acquire this knowledge. These conclusions apply to many other university mathematics courses. Textbooks are crucial tools for teaching and learning, serving as carriers of knowledge transfer. Therefore, authors should consider students' actual needs and integrate mathematical history into the content, ensuring students develop a profound understanding of the subject matter.

For universities and instructors using classic mathematics textbooks, there is no need to replace the textbooks. Instead, supplementary materials can be developed that focus on the historical context of mathematical concepts. These materials can serve as additional references for both students and instructors. Such supplementary readings are valuable for students who may struggle to find historical information related to specific mathematical topics and may not fully grasp the connections between the knowledge points and the history behind them. Furthermore, creating a repository of case studies that illustrate the integration of mathematical history into mathematics courses can provide a valuable resource for instructors when planning their teaching strategies.

4.3. Increasing the Depth and Breadth of Incorporating Mathematical History as an Ideological and Political Education Element

The concept of "curriculum ideological and political education" not only responds positively to the idea of "all courses should align with ideological and political theory courses" but also represents a new exploration in universities for reflecting on ideological attributes and uncovering moral education functions of courses in the new era [12]. When incorporating mathematical history as an ideological and political education element, it is essential to enhance its depth and breadth. Firstly, instead of providing simple historical facts about mathematical history, instructors should make every effort to gather authentic historical data related to the knowledge points and carefully analyze and select the relevant information for a more in-depth presentation of the ideological and political aspects of the content. Secondly, a comprehensive approach should be taken by not only focusing on Chinese mathematical history but also incorporating international mathematical history. This holistic view will broaden the ideological and political education perspective. In addition, instructors should emphasize the relationship between knowledge points and mathematicians as well as the process through which these knowledge points evolved. Lastly, it is crucial to ensure that the mathematical history materials integrated into the curriculum are well-grounded in historical accuracy, avoiding vague or unsubstantiated accounts when presented to students.

5. Conclusion

This article primarily discusses the necessity of incorporating the history of mathematics into university-level mathematics education from three aspects: as a teaching tool, an extension of textbooks, and as an element of ideological and political education. While it is essential to integrate mathematical history into mathematics courses, there are several challenges in practice. These issues can be summarized into three categories, as elaborated in the article. In real-world teaching, instructors should continue conducting multidimensional research, constantly refine strategies and theories for incorporating mathematical history into university courses, and enhance both teaching effectiveness and student learning outcomes.

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