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Teaching and Practice of Mathematical Modeling in Local Undergraduate Colleges

Zhiqiang Xiao*

College of Mathematics and Physics, Taizhou University, Taizhou 225300, China

***Corresponding author:** Zhiqiang Xiao, zhiqiang102@126.com

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Abstract: This paper primarily explores the teaching and practical application of mathematical modeling in local undergraduate universities. The discussion encompasses various aspects including teaching methodologies, scientific research, practical competitions, and collaborations with industry. By drawing upon personal experiences and reflecting on deficiencies observed in teaching and research, the paper provides insights into the subsequent teaching practices of this course. Emphasis is placed on the importance of integrating teaching and research practices to enhance talent development, promote disciplinary coordination, and advance the establishment of high-quality applied undergraduate institutions.

Keywords: Mathematical modeling; Personnel training; Scientific research practice; School-enterprise cooperation

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1. The development of mathematical modeling and teaching and research status

The teaching and practice of mathematical modeling are increasingly garnering attention from universities, educators, and students due to its applicability, interdisciplinary nature, and practicality. As of last year, 1,685 colleges and campuses domestically and internationally, with 59,611 teams (comprising 54,158 undergraduate teams and 5,453 junior college teams), totaling nearly 180,000 individuals, have registered for modeling competitions. Over the past three decades, these competitions have witnessed significant development, marking a commendable achievement. Presently, modeling competitions have expanded to include participation from middle school students and graduate students, with a proliferation of competitions at various levels, both regionally and internationally. This proliferation underscores the crucial role of modeling competitions in fostering talent, promoting interdisciplinary research, and facilitating industrial application.

Since the tenure began at a local undergraduate university in 2020, the author has been actively engaged in teaching modeling courses and guiding students in competition participation, in addition to collaborating with the institution to explore effective teaching and competition practices. However, the current landscape of teaching practice presents several challenges, such as the disconnect between teaching and research and insufficient student engagement in competition preparation. In pursuit of fostering the discipline's long-term development, the author aims to share his insights and experiences concerning talent development programs,

pedagogical strategies, involvement in scientific research projects, competition preparation, and collaborations with industry partners.

2. Curriculum construction and personnel training

The mathematical modeling course serves as an elective for students majoring in mathematics and primary education at our institution. According to the talent training program established in 2018, mathematics majors are eligible to enroll in four credits of mathematical modeling and mathematical experiment courses, while mathematics majors in primary education may opt for two credits of mathematical modeling courses. These elective courses are exclusively offered during the spring semester, with the modeling course for mathematics majors structured into theoretical and practical components.

The theoretical segment utilizes the textbook authored by Jiang *et al*. [1] and spans the first nine chapters, comprising 48 hours of instruction. Supplementary materials from domestic and international sources are also referenced [2-4]. The practical aspect, lasting 16 hours, employs the textbook "Mathematical Modeling and Mathematical Experiment" edited by educators such as Dan and Zhao [5]. This section elucidates essential models, programming techniques, and problem-solving methodologies.

Theoretical classes are conducted over the initial twelve weeks, followed by four weeks dedicated to practical sessions. Despite some adjustments to teaching methodologies and content over the past three years, overall outcomes remain unsatisfactory, evidenced by suboptimal student performance in both coursework and competitions. Key issues include the inadequacy of course content and programming training, deficient practical training, and insufficient coordination between coursework and paper composition.

Addressing these concerns, the institution has undertaken significant revisions to the new talent training framework. The elective course encompassing mathematical modeling and mathematical experiment is now divided into two separate courses: mathematical software, mathematical experiment, and mathematical modeling. During the fall semester, students will engage in the mathematical software and mathematical experiment course, comprising two classes per week over 16 weeks, yielding 2 credits. Instruction will draw from textbooks edited by educators like Dan and Zhao, providing students with a foundational understanding of mathematical modeling software and associated models.

Students demonstrating heightened interest and proficiency are encouraged to participate actively in modeling club activities and competitions, thereby enhancing their practical modeling capabilities and experience. Throughout the winter break, online discussion sessions will be organized to facilitate student engagement with exemplary papers in mathematical modeling and participation in relevant competitions, both domestic and international.

In the subsequent spring semester, a three-credit mathematical modeling course will be offered, retaining the framework based on the models compiled by Jiang and colleagues. Following a semester of study, students will possess a foundational grasp of mathematical modeling, enabling further exploration of related topics. Encouragement and support will be extended to interested and capable students to partake in the MathorCup University Mathematical Modeling Challenge and analogous competitions, thereby augmenting their practical modeling skills and proficiency.

Furthermore, consideration will be given to students' career aspirations and intentions when structuring teaching content. Approximately 70% of our university's graduates pursue employment annually, primarily in middle schools. The latest training objectives for middle school mathematics emphasize the acquisition of core competencies in mathematical modeling [6-8]. Consequently, the initial five weeks of the modeling course will

feature elementary model content, aligning with students' foundational knowledge from middle and high school. This approach aims to bolster students' confidence and motivation by reinforcing fundamental mathematical concepts.

Instruction will encompass the examination of mathematical modeling in domestic and international middle school contexts [9-11], as well as the application of mathematical models across relevant disciplines, fostering interdisciplinary aptitude and enhancing overall competency. Subsequently, topics will be expounded upon, intertwining disciplinary problems and content to broaden modeling methodologies and deepen students' comprehension of interdisciplinary relationships.

Lastly, recognizing that certain students intend to pursue advanced studies, master's program specializations pertinent to mathematical modeling will be introduced to guide students in targeted exploration.

3. Implementation and improvement of research projects

Regarding scientific research projects, the focus lies on teacher-led teaching and research endeavors, student innovation initiatives, and collaborations with industry. Applications have been made for university-level, provincial, and supra-provincial teaching and research projects, alongside guiding students in pursuing provincial and university-level innovation projects. Drawing upon previous experiences in scientific research projects, the author aims to elucidate strategies for enhancing research endeavors and personnel development.

Over the past three years, successful acquisition of relevant scientific research projects has been achieved. For vertical discipline projects, where foundational knowledge is profound but students lack requisite research skills, challenges arise in conducting comprehensive activities. Thus, the discussion will primarily center around guidance experiences and potential enhancements, integrating insights from teaching talent and innovation projects.

Leveraging mathematical modeling and mathematical experiment courses, an endeavor was initiated to explore teaching practices through competition. Over approximately three years, the project yielded notable achievements, including four awards from provincial competitions and above, completion of three papers, attainment of the title "MathorCup Excellent Mathematical Modeling Instructor," and presentation of a group report at the 18th Conference on Mathematical Modeling and Its Application in Lanzhou. Moreover, the establishment of a mathematical modeling society at our institution has further facilitated progress in teaching and competition practices. However, challenges persist in content arrangement, course coherence, and competition organization and guidance. Issues encompass the lack of coherence between theoretical and practical course components, insufficient integration between related courses such as probability theory, mathematical statistics, and ordinary differential equations, and the absence of standardized and effective guidance for domestic and international modeling contests. Future endeavors will focus on targeted improvement through adjusted teaching plans, reinforced interdisciplinary connections, adoption of best practices from peer institutions, and sustained efforts over a three-year timeframe.

Project implementation encountered numerous obstacles, beginning with topic selection during the application phase. Initial discussions centered on prevalent societal issues, with subsequent intermittent progress facilitated through online platforms. Despite challenges posed by the topic's theoretical complexity and data collection constraints, regular discussions and references to relevant literature culminated in successful project completion. Reflecting on this experience, the author advocates for selecting suitable topics and leveraging available resources for implementation. Subsequent guidance endeavors, tailored to students' knowledge base and career aspirations, yielded smoother progress, resulting in the publication of two papers and accolades in

prestigious competitions. Future endeavors will focus on continued improvement and refinement, with sustained investment in topic determination, team selection, preliminary exploration, and subsequent research to ensure high-quality outcomes.

Horizontal collaboration with industry remains in the exploratory phase. Participation in meetings on the application of mathematical modeling in enterprises provided valuable insights into industry demands for mathematical talent, alongside the processes and challenges associated with horizontal projects. Consultations with experts from academia and industry yielded diverse perspectives on topic selection and project engagement. Future efforts will involve further exploration and cooperation with enterprises and public institutions to effectively translate knowledge into practice.

4. Community establishment and competition training

To enhance the development of modeling activities, the university has sanctioned the establishment of a school-level mathematical modeling association. With support from the mathematical modeling community, the initiative aims to actively conduct supplementary modeling activities and broaden the reach of mathematical modeling. The association regularly hosts various modeling activities, encompassing specialized training sessions, thesis discussions, experience exchanges, and related endeavors. Thematic activities occur biweekly, featuring participation from teachers and students who have excelled in modeling competitions and earned accolades as keynote speakers. Additionally, weekly thematic activity is arranged, amalgamating online video resources and relevant materials [12-15]. Participants are encouraged to preview materials in advance, engage in discussions during offline sessions, and receive prompt feedback from instructors. During lectures, participants scrutinize exemplary papers from pertinent events, with designated groups tasked to review and discuss them meticulously before each session, followed by the participation of relevant team members in discussion classes. This integrated approach, combining thematic topics with relevant events, facilitates continual improvement in students' modeling skills and performance. Moreover, systematic summer modeling training sessions are conducted, focusing on specialized topics and authentic problems, leveraging resources both within and outside the institution to blend online and offline training. Students are motivated to actively participate in the Shenzhen Cup and Huashu Cup summer modeling competitions, thereby refining their practical experience through hands-on exercises. Furthermore, students' practical skills are further honed through simulated combat exercises. Concurrently, efforts are made to secure relevant teaching and research projects pertaining to mathematical modeling, with students actively engaged in interdisciplinary teaching and research activities, competition question analysis, and the distinct characteristics of various competition levels. These concerted endeavors contribute to the practical development of modeling activities, bolster students' subsequent growth, foster interdisciplinary research, and facilitate social engagement, thereby elevating the institution's status as a premier applied undergraduate university.

5. Exploration and related prospects of school-enterprise cooperation

Finally, let's delve into university-enterprise collaboration. Currently, modeling training at the institution is still in its nascent stages, and competition outcomes have yet to reach remarkable heights. However, from the standpoint of enhancing students' practical abilities, bolstering comprehensive quality, and augmenting the institution's capacity to serve the local community, the author believes that school-enterprise cooperation is an inevitable pathway. This collaborative endeavor promotes talent cultivation, fostering the healthy and sustainable development of disciplines and related sectors, while also facilitating the institution's local outreach

efforts. It is essential to remain attentive to and draw lessons from existing models and cases, aspiring to glean valuable insights and chart a developmental trajectory aligned with unique circumstances and promising prospects.

In recent years, the Society of Industrial and Applied Mathematics has actively orchestrated endeavors with the business community to foster exchanges and collaboration among universities, research institutes, enterprises, and institutions. The Forum on Mathematics for Enterprise Innovation and Development, held over three successive sessions, has yielded notable achievements. Each session of the Forum selects a theme and identifies crucial issues urgently requiring resolution within relevant fields. By catalyzing teams to address these challenges through open problem-solving approaches, fruitful exploration has ensued across domains such as communication, aviation, and medicine. The author remains committed to monitoring these developments, engaging in ongoing discussions and exchanges with experts in relevant fields, and endeavoring to align the academic foundation of the institution with local industrial dynamics, structural characteristics, and current focal areas. This approach aims to forge an applied practice pathway tailored to unique attributes, thereby making a modest contribution to the continued advancement of the academic community.

In conclusion, excelling in the teaching and research of mathematical modeling and fostering school-enterprise cooperation necessitates sustained effort and continuous learning. In subsequent teaching and competition guidance endeavors, efforts will persist in summarizing experiences and effecting improvements, with the overarching goal of contributing to the long-term development of students and the institution.

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