

Research on the Application of Mathematical Software (Mathematica/GeoGebra) in Higher Vocational Mathematics Teaching

Yunhong Zhang

College of Public Basic Courses, Shanghai Technology and Innovation Vocational College, Shanghai 201620, China

Corresponding author: Yunhong Zhang (e-mail: 18918289773@163.com)

ABSTRACT Improving the effectiveness of higher vocational mathematics education remains challenging due to diverse student backgrounds, limited learning motivation, and difficulties in understanding abstract mathematical concepts. To address these issues, this study investigates the application of Mathematica and GeoGebra in higher vocational mathematics teaching through a quasi-experimental approach. Two parallel classes were selected as experimental and control groups, respectively. The proposed teaching framework integrates conceptual visualization, computational demonstration, professional case modeling, and interactive exercises into the courses of Advanced Mathematics and Probability Theory. Teaching effectiveness was evaluated through academic performance, software task completion rates, online participation records, and questionnaire feedback collected over one academic year. Results indicate that students receiving software-assisted instruction achieved higher examination scores and demonstrated improved understanding of abstract mathematical concepts and application-oriented problem-solving abilities. The findings confirm that the integration of mathematical software enhances visualization, modeling capability, and analytical thinking. The proposed framework also provides educational support for mathematical modeling, signal analysis, and engineering computation in fields related to electromagnetic systems and communication technologies.

INDEX TERMS mathematics education, Mathematica, GeoGebra, mathematical modeling, engineering computation

I. INTRODUCTION

A GAINST the background of higher vocational education aiming to develop professionals with specialized training, mathematics courses serve as essential foundations that directly influence the logical thinking and quantitative analysis required for complex engineering tasks, such as calculating material interlacing geometry and material density. Mastering these mathematical principles ensures that students possess the analytical rigor necessary for subsequent professional learning in advanced processing technology and the structural mechanics of However, current higher vocational mathematics teaching is generally facing a structured materials dilemma: on the one hand, the course content itself has a certain degree of abstraction and logical rigor; on the other hand, higher vocational students have diversity and differences in mathematical foundation, learning habits, and cognitive characteristics, with many students suffering from significant “mathematical anxiety” being felt or having difficulty and alienation against formal symbolic derivations and theoretical proofs. This discrepancy between the high

demands of the teaching content and the actual learning situation of the students often leads to poor teaching results, a steady decline in student motivation and the mathematics course does not achieve its intended educational function.

The conventional teaching mode of “teacher lectures, students listen, and practice after the class” often does not successfully establish intuitive and dynamic cognitive schema in the mind of students when used in the teaching of such abstract fundamental concepts as limits, derivatives, integrals, and probability distributions. Students succumb easily to the pitfall of rote memorization of formulas and problem-solving routines without understanding the essential connotations of mathematical concepts and their useful application value in such fields as engineering technology and economic management. This worsens the “learning without application” image as well as intrinsic motivation for learning. Therefore, to seek out a new teaching model to lower the cognitive threshold, establish intuitive understanding, and to closely link with the application in the professional field has become an urgent need to solve

the dilemma of teaching mathematics at higher vocational colleges.

With the rapid development of educational informatization technology since then, professional mathematical software such as Mathematica and GeoGebra have become powerful technical tools for teaching reform. Mathematica is known for its advanced form of symbolic computation, numerical analysis, and high-level programming capabilities among others excelling at its ability to perform complex mathematical operations and construct models, while GeoGebra is recognized for its capacity for dynamic visualization and interactive exploration of geometry, algebra, and calculus where it can convert abstract mathematical relations into intuitive graphical images. Theoretically, the combination of these two software programs can cover the whole chain of the learning of mathematics, from the intuitive perception to in-depth analysis, from theoretical verification to the practice. However, the organically, efficiently and systematically combining these two software programs into the daily teaching of vocational college mathematics, design teaching activities that conform to the cognitive pattern and professional needs of vocational college students and scientifically evaluate their actual teaching effectiveness is still an exploration and practical verification topic. This study has the aim to systematically study the integrated application model of Mathematica and GeoGebra software in the higher vocational mathematics teaching. Through specific teaching practices involving the mathematical modeling of interlacing and density, this study verifies the effectiveness of the model and summarizes a set of material teaching implementation paths that can be promoted within engineering vocational programs. These results provide a practical reference for improving the quality of mathematics instruction, ensuring that the training of technical personnel aligns with the quantitative analytical skills required for modern processing and production.

II. RELATED WORK

In higher mathematics education research, the connection between academic stages, the innovation of teaching models and the application of technological tools have become core issues. Ko et al. [1] revealed the differences between university teachers and high school teachers in identifying and prioritizing teaching obligations. Qiao and Yu [2] proposed an enhanced group decision-making algorithm, designed a new information aggregation operator to integrate the opinions of multiple experts, and obtained the final teaching quality evaluation results through the ranking method. Xi and Bo [3] explored the reform path of university mathematics teaching model under the background of new engineering. Taley [4] revealed the perception level of college students' sense of teaching presence in emergency remote online mathematics teaching and analyzed the differences in the impact of different dimensions. Liu and Yin [5] explored from the perspective of educational psychology whether it is possible to intervene and alleviate students' mathematics learning

anxiety, or even more extensive anxiety symptoms, by optimizing mathematics teaching itself (rather than simple psychological counseling).

There is a significant gap between high school and university mathematics in terms of knowledge content, thinking methods and teaching pace, which leads to many freshmen having difficulty adapting to learning.

Jiang et al. [6] explored how to strengthen the connection between the two stages of mathematics education through teaching practice and help students transition smoothly. Wei and Li [7] adopted a hybrid research method combining structural equation modeling and fuzzy set qualitative comparative analysis, and verified the independent influence path of each factor on the teaching effect through SEM. The application of technology in university mathematics and statistics teaching is becoming increasingly widespread. Bukhatwa et al. [8] evaluated the practical utility of technology-based interactive methods in undergraduate teaching. Yijia [9] explored the content, form and evaluation concept of college entrance examination mathematics, and how they reflect and influence the mathematics teaching practice and research at the university stage. Zeng and Tang [10] explored whether the reform of mathematics teaching model can have a positive intervention effect on anxiety disorder. This paper focuses on the application of mathematical software (Mathematica/GeoGebra) in higher vocational mathematics teaching. It aims to explore new teaching paths that adapt to the cognitive characteristics and professional needs of higher vocational students under the empowerment of technology, in order to provide a reference for alleviating the teaching dilemma of higher vocational mathematics and improving the effectiveness of education.

III. METHODS

A. RESEARCH SUBJECTS AND EXPERIMENTAL DESIGN

This study selected two parallel classes which are from the 2023 higher vocational college cohort with similar professional backgrounds and no significant difference between the average of their entrance mathematics scores as research subjects. One class (52 students) was declared as the experiment group and the other class (50 students) the control group. Both groups had the same mathematics teacher and used the same textbooks (Tongji University's "Advanced Mathematics," 7th edition, and the college's own "Probability Theory and Mathematical Statistics"). The pace of teaching and the overall class hours was the same. The most essential distinction was the intervention methods in the teaching process: in the experimental group, the Mathematica and GeoGebra software could be systematically introduced into the whole teaching process; in the control group, the traditional lecture-type teaching supplemented by multimedia teaching courseware were used. The time frame for the research was a full academic year, which includes two semesters, the primary classes to be studied are Advanced Mathematics and Probability Theory and

Mathematical Statistics. This study was approved by the Ethics Committee of Shanghai Technology and Innovation Vocational College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

B. DESIGN AND IMPLEMENTATION OF INTEGRATED APPLICATION SCHEME FOR TEACHING SOFTWARE

Based on the basic knowledge points and competency requirements of vocational college mathematics courses, this study developed a dual-software integration scheme designed to balance cognitive load: GeoGebra was used exclusively for low-stakes conceptual discovery to prevent overstimulation, while Mathematica was reserved for high-level computational modeling. To isolate the software's impact from general pedagogical shifts, the control group was also engaged in active learning through traditional problem-solving workshops and multimedia-based collaborative discussions. This ensures that the observed improvements in pass rates are specifically attributable to the computational and visualization affordances of the software, rather than a mere shift from passive to active instruction.

In the concept introduction and the visualization exploration phase, the GeoGebra software is mainly utilized. For example, in the explanation of the limit of sequences and functions, by dragging sliders, students are led to observe the changing trends of the terms of sequences and the process of approximating the function values to some point dynamically, so that the abstract description of "infinitely close" is transformed into an intuitive visual experience. When describing the geometrical meaning of the derivative, derivative tangent lines are built dynamically and then students see the change from secant to tangent in real time with a deep understanding of the derivative as the slope of the tangent line. When teaching the definition of definite integrals, an animation of "sum of rectangle areas" is used to dynamically demonstrate the process of division, approximating, summation and taking the limit, and make them intuitive to understand the abstract definition. In the probability and statistics part, the probability calculator in the GeoGebra software and the dynamic distribution plotting are used to illustrate intuitively the features and the characteristics and the probability meanings of binomial distribution and normal distribution.

In the part of complex calculations, symbolic derivation, and professional cases modeling, Mathematica software mainly used. For complex differentiation, integration, matrix operations, and differential equation solving involved in vocational mathematics, teachers model and coach students to use the symbolic computation functions of Mathematica, freeing them from the tedious calculations that would otherwise take up their time and be better spent on learning the problem model, choosing methods of solution, and analyzing results. More importantly, this study developed specialized modeling cases specifically for the engineering curriculum. For example, students used software to simulate

fiber morphology and the spatial distribution of materials within 3D structured architectures. By inputting parameters like material density and structure interlacing geometry, students visualized the geometric mechanics of structures through mathematical functions. For example, mechanical and electrical engineering students are shown how to use Mathematica to model and simulate the motion of mechanisms, to analyze the velocity and acceleration; economics and management students are shown how to use Mathematica to solve optimization problems, curve fitting and prediction of economic data; and computer science students are shown simple algorithm complexity analysis and graph generation. Through the process of "proposing a problem - building a model - solving with software - analyzing results," the application-oriented nature of mathematical knowledge is enforced.

Two software programs were used in combination in the teaching feedback and personalized practice sessions. Teachers used GeoGebra Classroom to create interactive classroom activities, publishing multiple choice and construction questions with dynamic graphical operations in real time, collecting feedback by the whole class immediately to accurately pinpoint areas of difficulty in understanding. After class, tiered software exploration tasks were assigned where the basic was to use GeoGebra to reproduce the classroom demonstration and change parameters to see changes, and the advanced task was to use Mathematica to do comprehensive calculation or simple application modeling problems (from the text). A learning platform was created, into which all tasks were submitted, so the teachers could monitor the progress and results of each student.

C. DATA COLLECTION AND EVALUATION TOOLS

To fully assess effectiveness in teaching, this study gathered data from various dimensions:

Academic performance data: The results of unified closed book examinations of "Advanced Mathematics" and "Probability Theory and Mathematical Statistics" held at the end of the academic year were collected from both the experimental and control groups. The examination papers were set all together by a third party teaching and research office (not the ones teaching the courses) in accordance to the teaching syllabus to assure reliability and validity.

Learning process data: Via the back-end of the online learning platform, the data on the submission rate of GeoGebra interactive tasks, the completion rate of mathematica modeling assignments and the average score of online quizzes in corresponding chapters throughout the academic year were collected from experimental group students.

Questionnaire data: To control for the Hawthorne Effect and identify whether shifts in motivation were specifically software-driven, the same questionnaire was distributed to both the experimental group (N=52) and the control group (N=50). The questionnaire adopted a five-point Likert scale across five dimensions, allowing for a comparative baseline of the learning experience under traditional versus

software-assisted instruction. Open-ended questions were also added to gather qualitative feedback. The reliability of the questionnaire was 0.87. However, recognizing the potential for social desirability bias given the high agreement rates (>84%) and the small sample size (N=52), the survey was administered anonymously via a third-party platform. Furthermore, triangulation was employed by comparing self-reported interest with objective ‘Learning Process Data’ (such as software task completion rates) to ensure that students’ positive attitudes were reflected in their actual academic engagement.

Specialized Comprehension Test: Within one week after completion of teaching four core and challenging modules namely “Limits”, “Applications of Derivatives”, “Applications of Definite Integrals” and “Normal Distribution”, two groups of students will be subjected to a specialized conceptual comprehension test. The test questions will not consist complicated calculation and will mainly be focused on the understanding of the essence, the geometric meaning and the practical implication of the concepts. The question types will include mainly multiple choice and short answer questions[11]. To ensure the test measured conceptual depth rather than just visual recognition, questions were designed to require logical reasoning. For example, students were asked to describe the physical meaning of a derivative’s sign in the context of tension changes, or to material identify the convergence conditions of a sequence without relying on a graph. This ensures the assessment remains a neutral measure of mathematical ‘essence’ rather than a bias toward software visualization.

IV. RESULTS AND DISCUSSION

A. COMPARATIVE ANALYSIS OF ACADEMIC PERFORMANCE

The final exam results are the most direct quantitative indicator for measuring teaching effectiveness. Statistical analysis of the final exam scores of the experimental and control groups is shown in Figure 1.

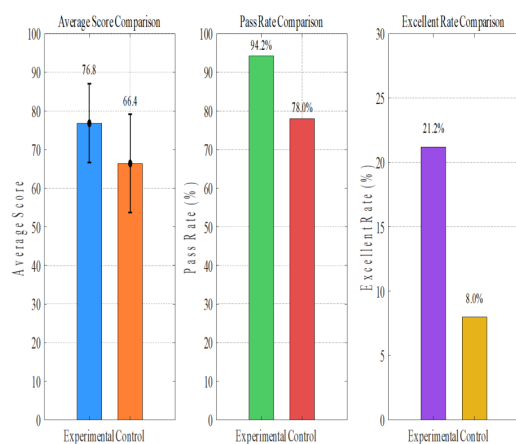


FIGURE 1. Comparison of scores between the experimental group and the control group

As shown in Figure 1, the experimental group significantly outperformed the control group in many aspects of academic performance. The average score of the experimental group (76.8 points) was 10.4 points higher than that of the control group (66.4 points), representing an improvement of approximately 15.7%. This difference is significant, indicating that software-assisted instruction has a positive effect on students’ final knowledge acquisition and comprehensive application abilities. The pass rate of the experimental group was as high as 94.2%, while that of the control group was 78.0%, a difference of 16.2 percentage points. This demonstrates that the teaching model effectively reduced the risk of widespread failure and helped more students meet the basic requirements of the course. In terms of the rate of excellence reflecting higher-level learning outcomes, the experimental group (21.2%) was 2.65 times that of the control group (8.0%). This indicates that software-assisted instruction not only helps to “support the bottom” but also “elevates” the level, providing a platform for students with extra learning capacity to explore and apply their knowledge in depth, thus stimulating their potential. The comparison of the standard deviation of scores (experimental group 10.2 vs control group 12.7) reflects a more concentrated performance distribution in the software-assisted class. To maintain statistical integrity, Figure 1 has been redrawn with error bars precisely calibrated to these standard deviation values, ensuring the visual representation of data dispersion is mathematically consistent with the reported numerical results.

B. IN-DEPTH ANALYSIS OF THE LEARNING PROCESS AND CONCEPT COMPREHENSION

Beyond final grades, students’ performance throughout the learning process and their understanding of core concepts reveal the deeper impact of teaching models. Evidence is provided by the results of specific comprehension tests and process data, as shown in Table 1.

TABLE 1. Comparison of Core Concept Understanding Test Accuracy and Process Data

Evaluation Project	Average accuracy/comprehension of the experimental group	Control group average accuracy/comprehension	Difference (percentage points)
Limit Concept Comprehension Test	85.4%	61.8%	+23.6
Test on the geometric meaning of derivative	88.7%	68.5%	+20.2
Definite Integral Definition Comprehension Test	82.1%	60.2%	+21.9
Test on understanding the properties of normal distribution	87.9%	66.0%	+21.9
Average accuracy rate of concept comprehension	86.0%	64.1%	+21.9

Table 1 shows the significant advantages of software-assisted instruction in promoting students’ deep understanding. In the specialized tests on the four core concepts, the experimental group achieved an average accuracy rate of 86.0%, far exceeding the control group’s 64.1%, a lead of 21.9 percentage points on average. In the most abstract concept of “limit,” the gap reached 23.6 percentage points. This strongly demonstrates that GeoGebra’s dynamic visualization function can transform abstract thinking such as “infinite approximation” and “trend” into intuitive visual dynamics, greatly reducing students’ cognitive load and promoting the construction of meaning for abstract concepts.

The tests on the geometric meaning of derivatives and integrals also showed a significant difference, verifying the bridging role of dynamic graphics in connecting algebraic forms with geometric intuition.

C. COMPREHENSIVE EVALUATION OF STUDENTS' LEARNING EXPERIENCE AND ATTITUDE FEEDBACK

Students' acceptance of teaching methods and their subjective feelings are important dimensions for evaluating the success of teaching reform. The results of the questionnaire survey of the experimental group students are summarized in Table 2.

TABLE 2. Results of the Questionnaire Survey on Learning Experience of Students in the Experimental Group (N=52, Percentage %)

Questionnaire Dimensions and Representative Statements	I completely agree	I agree	Generally agree	Disagree	I strongly disagree	Positive agreement
Software usability perception: I think GeoGebra/Mathematica software is easy to learn and use.	25.0	59.6	13.5	1.9	0.0	84.6
Enhanced conceptual understanding: The software's graphical/dynamic demonstrations helped me better understand abstract mathematical concepts.	40.4	48.1	9.6	1.9	0.0	88.5
Changes in learning interest: Using software to learn math has made me find math more interesting than before.	32.7	51.9	13.5	1.9	0.0	84.6
Anxiety relief perception: Through software verification and exploration, I am less nervous and afraid when doing math problems.	28.8	55.8	13.5	1.9	0.0	84.6
Recognition of application value: By solving professional cases through software, I have come to realize even more that mathematics is useful.	36.5	50.0	11.5	1.9	0.0	86.5

The results of the questionnaire with respect to students' own subjective experiences supported the validity of the quantitative data. In all five key dimensions, the combined percentage of those students who agreed "strongly agree" and "agree" was over 84% demonstrating a very positive learning experience. Specifically, about "enhanced concept understanding" 88.5% of students admitted that the software visualization helped them in understanding abstract concepts and this is in line with the high accuracy percent of the specialized tests. Notably, 84.6% of students perceived an increase in learning interest and the same (84.6%) perceived their anxiety about learning mathematics was reduced. This directly solves the dilemma of "mathematical anxiety" and the lack of motivation among vocational college students mentioned at the beginning, so vivid software environments with intuitive and interactive features can effectively improve the emotional learning experience of students, and reduce psychological barriers. A high percentage (86.5%) of students increased their understanding of the applied value of mathematics by modeling professional case. Modeling and applying cases helps deal with cognitive bias of "learning without application". "Learning without application" transforms the learning of mathematics from "accepting knowledge passively" to "actively exploring tools", which is consistent with the purpose of cultivating applied-oriented talents in vocational education. In the open-ended feedback, students often said that "graphics bring knowledge to life," "it's fun to see the changes when adjusting parameters by hand," "it's very rewarding to solve complex equations with Mathematica," "I never thought that mathematics could be used to solve professional problems in this way," which further added to the meaning of the above quantitative data from a qualitative perspective.

Based on the results and discussion from the above three dimensions, it can be concluded that the systematic

utilization of both Mathematica and GeoGebra software in the teaching of mathematics in vocational colleges not only has a significant effect on the students' academic performance and the depth of their understanding of the core concepts, but also have a significant effect on the learning experience of the students and foster their interest in the learning process, reduce the anxiety of the learning materials and enhance their recognition of the importance of applied mathematics. This teaching model is an effective way of addressing some of the main challenges that vocational college teaching of mathematics is facing in a multi-pronged approach of "visualization to lower the barrier to entry, interaction to increase participation, and application to clarify value."

V. CONCLUSION

This study, through a one-year quasi-experiment, systematically explored the integrated application model of Mathematica and GeoGebra in vocational mathematics teaching by simulating the geometric mechanics of interlacing and density. By visualizing these complex structural parameters through dynamic software modeling, the research demonstrates how digital tools enhance the quantitative analytical skills required for precision and high-end processes. The results show that this technology-enabled teaching reform approach is feasible and efficient. Specifically, this study reached the following conclusions.

First, the application of the software effectively improved teaching effectiveness. Students in the experimental group significantly outperformed the control group, who used traditional teaching methods, in terms of quantitative indicators such as final exam scores, understanding of core concepts, and participation in the learning process. This confirms that using software as a core cognitive tool, rather than a simple demonstration tool, can effectively promote the construction of students' mathematical knowledge and abilities. Secondly, the application of the software has profoundly improved students' learning experience and emotional attitudes. Dynamic visualization reduces the cognitive load of abstract knowledge, interactive exploration empowers students with initiative and immersion in learning, and case modeling integrated with their majors builds a bridge between mathematical theory and professional practice. These factors work together to significantly enhance students' learning interest, alleviate widespread math anxiety, and transform math learning from a daunting task into an exploratory, interactive, and valuable cognitive process. Finally, this study explored and implemented a workable integrated teaching scheme. Based on the knowledge structure of vocational college mathematics and the cognitive characteristics of vocational college students, this scheme precisely positioned and collaboratively divided the functions of the two software programs, GeoGebra and Mathematica: GeoGebra focuses on the visualization and intuitiveness of concepts, while Mathematica focuses on the automation of calculations and the application of modeling.

The teaching implementation spans before, during, and after class, integrating the geometric modeling of interlacing and the material calculation of density into a logical closed loop of concept exploration and professional application. By material embedding these specific engineering parameters into the entire process of verification and complex calculations, the methodology ensures that mathematical theory remains deeply connected to the structural mechanics of high-performance structured materials

AUTHOR CONTRIBUTIONS

Yunhong Zhang designed, collected and analyzed the data, and drafted the manuscript. Yunhong Zhang conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Yunhong Zhang participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

FUNDING

This research received no external funding.

HUMAN RESEARCH SUBJECTS

This study was approved by the Ethics Committee of Shanghai Technology and Innovation Vocational College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

- [1] I. Ko, P. Herbst, and M. Shultz, "Comparing how college mathematics instructors and high-school teachers recognize professional obligations of mathematics teaching when making instructional decisions," *Journal of Mathematics Teacher Education*, vol. 27, no. 6, pp. 1055-1082, 2024, doi: 10.1007/s10857-023-09595-2.
- [2] J. Qiao and J. Yu, "Enhanced GDM Algorithms for College Mathematics Teaching Quality Evaluation Under Interval-Valued Intuitionistic Fuzzy Sets," *International Journal of Web-Based Learning and Teaching Technologies*, vol. 19, no. 1, pp. 1-20, 2024, doi: 10.4018/IJWLTT.358748.
- [3] I. Xi L and I. Bo L, "Research and Practice of College Mathematics Teaching Mode under the Background of New Engineering," *Journal of nanchang hangkong university (Natural science edition)*, vol. 36, no. 4, pp. 134-138, 2022, doi: 10.3969/j.issn.2096-8566.2022.04.018.
- [4] B. Taley I, "College Students' Perceived Teaching Presence in Emergency Remote Online Mathematics Teaching," *Journal of Research and Advances in Mathematics Education*, vol. 7, no. 3, pp. 116-129, 2022, doi: 10.23917/jramathedu.v7i3.17589.
- [5] Z. Liu and H. Yin, "Optimization of mathematics teaching and learning for the treatment of anxiety disorders in college students," *CNS Spectrums*, vol. 28, no. S2, pp. S22-S22, 2023, doi: 10.1017/S1092852923003036.
- [6] Z. Jiang, Y. Yang, X. Zhang, et al., "Teaching Consideration and Practice on the Connection of Mathematics at Senior High School and College," *Journal of Innovative Technology and Education*, vol. 10, no. 1, pp. 1-5, 2023, doi: 10.12988/jite.2023.1030.
- [7] L. Wei and C. Li, "Uncovering Influencing Mechanisms and Practical Strategies for Teaching Effectiveness of College Mathematics General Education Courses: Evidence from SEM-fsQCA Hybrid Analysis," *Academic Journal of Emerging Technologies*, vol. 2, no. 2, pp. 20-28, 2026, doi: 10.63313/AJET.9034.
- [8] B. Bukhatwa, A. Al Ruqeishi E N, and H. Al Khamisi F M, "The Usefulness of Technology-Based Interactive Methods in Teaching Mathematics and Statistics at the College Level," *Shanlax International Journal of Education*, vol. 10, no. 3, pp. 30-40, 2022, doi: 10.34293/education.v10i3.4627.
- [9] C. Yijia, "Research and Practice of Mathematics Teaching in College Entrance Examination," *Academic Journal of Mathematical Sciences*, vol. 4, no. 1, pp. 56-60, 2023, doi: 10.25236/AJMS.2023.040109.
- [10] X. Zeng and G. Tang, "The intervention effect of mathematics teaching model reform on social anxiety disorders of college students," *CNS Spectrums*, vol. 28, no. S2, pp. S89-S89, 2023, doi: 10.1017/S1092852923004753.
- [11] X. Shen, "A classification method of College Mathematics MOOC teaching resources based on machine learning," *International Journal of Continuing Engineering Education and Life Long Learning*, vol. 34, no. 4, pp. 314-326, 2024, doi: 10.1504/IJCEELL.2024.139944.