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Practice of Hybrid Teaching of Advanced Mathematics Based on Artificial Intelligence

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Abstract: *With the rapid development of intelligent educational technologies, traditional higher-level mathematics instruction is plagued by widespread problems such as inefficient resource utilization, insufficient personalized instruction, and low student learning initiative. To address these shortcomings, this paper introduces artificial intelligence and big data analysis technologies to construct an AI-driven online and offline hybrid teaching model for higher-level mathematics. Intelligent learning analysis enables accurate identification of student knowledge mastery. A dynamic question bank and visual auxiliary resources enable real-time adaptation of learning resources. The "Cloud Classroom" platform provides intelligent feedback and dynamic adjustment of classroom interactions, comprehensively enhancing detailed control over the teaching process. An empirical study, conducted on undergraduate engineering students, designs a controlled experiment. Results show that the experimental group, with a mean score of 78.2, outperforms the control group (68.5) on the interim test, with a significant difference (p=0.003), demonstrating the sustained superiority of the AI hybrid teaching model in interim learning outcomes. Finally, the pass rate indicator shows a statistically significant 98.0% for the experimental group and 86.0% for the control group (p=0.014), further validating the effectiveness of this teaching model in reducing the risk of failure. The research results verify the significant advantages of blended teaching empowered by artificial intelligence in improving the accuracy and effectiveness of higher mathematics teaching.*

Keywords: *Hybrid Teaching of Advanced Mathematics; Artificial Intelligence; Big Data Analysis; Intelligent Learning Situation Analysis; Personalized Teaching*

1. Introduction

Against the backdrop of rapid developments in information technology, artificial intelligence (AI) and big data technologies are profoundly transforming higher education teaching models. In the field of advanced mathematics, in particular, traditional "cramming" lectures and single textbook resources are no longer able to meet the increasingly diverse and personalized learning needs of vocational undergraduates. Numerous studies have pointed out that advanced mathematics courses are generally plagued by problems such as insufficient student motivation, fragmented knowledge acquisition, low classroom participation, and weak practical application skills. These problems seriously hinder the effective transfer of mathematical knowledge and the foundation for subsequent professional courses.

To this end, this paper integrates artificial intelligence and big data to design a comprehensive, intelligent hybrid teaching model encompassing pre-, in-, and post-class instruction. Through intelligent student situation analysis, dynamic resource generation, real-time classroom feedback, and targeted training for weak areas, this paper constructs a new model for advanced mathematics instruction that incorporates multi-dimensional interaction and real-time optimization, aiming to improve students' learning accuracy, classroom engagement, and practical application capabilities. Through empirical controlled experiments, this paper systematically validates the effectiveness of AI-enabled hybrid instruction and explores its application in the reform of advanced mathematics instruction for vocational undergraduates, providing practical insights for the development of intelligent education.

2. Related Works

In recent years, research on the application of digital technologies and intelligent means in

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mathematics education has continued to grow. Many scholars have explored the impact of AI, gamification, curriculum reform, and teacher professional development on teaching effectiveness from different perspectives. The following summarizes some representative research results.

Chen et al. designed an online gamified learning activity that combined multiple representational scaffolds and compared its effects on high school students' learning achievement and motivation with those of ordinary synchronous distance learning. The results showed that gamified learning did not significantly improve grades, but significantly improved learning motivation [1]. Wasserman et al. focused on the role of university mathematics in the training of secondary school mathematics teachers and explored related issues and challenges. Through a semi-systematic literature review, they sorted out theoretical distinctions and solution paths and compiled research results from multiple countries [2]. Shirawia et al. investigated the logical-mathematical intelligence level of female mathematics teacher trainees and its impact on academic performance. The results showed that students' logical-mathematical intelligence was generally high (average 3.71), their academic performance was good (72.7% good, 25% excellent), and there was a significant positive correlation between intelligence level and mathematics performance, indicating that logical-mathematical intelligence had a positive impact on academic performance [3]. Nguyen and Tran explored the impact of curriculum training on the knowledge and beliefs of Vietnamese high school mathematics teachers, emphasizing the importance of cultural background. The results showed that teachers improved their professional content knowledge, transformed their curriculum implementation roles, and improved teaching design and evaluation by paying attention to students' thinking and cognitive conflicts [4]. Liang et al. focused on three secondary mathematics teacher trainees in Hong Kong and explored their identity and knowledge construction in university and secondary school mathematics classrooms, revealing the manifestation of the "dual rupture" phenomenon in the local cultural context. The study found that there was coherence between the two environments [5]. Fitriati et al. improved the lesson preparation ability of 13 mathematics teacher trainees through school-enterprise cooperation teaching and research activities. The results showed that the 16 categories of problems in the first draft were reduced to 6 categories in the final draft, with an improvement rate of 62.5% [6]. Karim and Zoker analyzed the views of Masinbi high school mathematics teachers on technology-integrated teaching through questionnaires and interviews. Although teachers recognized the advantages of technology teaching, teaching beliefs, lack of continuous training and curriculum requirements became the main obstacles [7]. Zbiek et al. used a retrospective method to explore the experience of secondary school mathematics teachers in understanding and teaching mathematical modeling. The results showed that teachers experienced cognitive challenges and reflections in mathematical knowledge, learning sociality, real-life situations, student thinking and curriculum, which promoted their professional growth. The study emphasized the complex learning trajectory of teachers as lifelong learners and provided a new perspective for teacher education [8]. Aldemir Engin et al., based on the Niess (2013) model, explored methods to improve the development of TPACK (Technology, Pedagogy and Content Knowledge) in mathematics teacher training students. Through interviews, lesson plans and micro-teaching data, they proposed a revised model to help teacher educators optimize training programs and improve the ability of teacher training students to integrate technology and subject teaching in the digital age [9]. Pino-Fan proposed a teaching mathematics knowledge model, which aims to integrate teacher knowledge and professional ability and solve the separation problem of existing models. The model provides theoretical and methodological support for the core knowledge and skills in the professional practice of mathematics teachers, refines the categories and subcategories of abilities required for teaching, and contributes to the development of teacher training and teaching research [10]. Weigand et al. explored the transformative role of digital technology in mathematics teaching, learning and assessment, focusing on the cultivation of teachers' digital and mathematical abilities, innovative teaching design and long-term support projects. This study emphasizes the integration of diverse learning resources and the potential for personalized assessment under technology support, pointing out the direction for the future application and research of mathematics education technology [11]. Existing research mostly focuses on a single dimension of teaching model or teacher development, and there is a general lack of in-depth verification of the precise intervention mechanism of intelligent technology and students' personalized learning outcomes.

3. Methods

3.1 Helping Precise the Teaching Process by Artificial Intelligence

Artificial intelligence technology has infused hybrid teaching of advanced mathematics with greater

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personalization and precision. Leveraging big data analysis and intelligent algorithms, the teaching system can comprehensively collect and mine multi-dimensional behavioral data from students during the learning process, such as online test results, duration and frequency of video learning, and engagement in classroom interactions. Through in-depth analysis of these learning behaviors, the intelligent system can effectively identify students' mastery levels of different mathematical knowledge points. For example, for certain students with weak areas in core knowledge such as limits, derivatives, and series, the system can provide real-time feedback on their learning status. Based on this, teachers can dynamically adjust the teaching pace, flexibly optimize classroom teaching content, and match more suitable learning paths for students of different levels, truly tailoring teaching to students' aptitude and effectively improving the relevance of teaching and learning efficiency.

3.2 Dynamic Generation and Intelligent Matching of Teaching Resources

Unlike traditional static textbooks and fixed exercises, hybrid teaching empowered by artificial intelligence can achieve dynamic generation and adaptive matching of teaching resources. By analyzing students' answers and learning feedback, the system can automatically push practice resources with appropriate difficulty and stronger pertinence. For content that students have mastered, the intelligent system automatically reduces the frequency of practice to reduce learning fatigue; for knowledge points that have cognitive difficulties, personalized reinforcement training questions are pushed to help students gradually overcome the difficulties. At the same time, for abstract concepts such as partial derivatives of multivariate functions and convergence of series, the system can intelligently generate animations, interactive visualization courseware and real-time explanation videos based on students' understanding, so that students can understand complex mathematical concepts more intuitively and continuously improve their learning interest and depth of understanding.

3.3 Integration of Teaching Resources and Optimization of Course Content

Supported by artificial intelligence, the hybrid teaching design of vocational higher mathematics focuses on the deep integration of resources and content reconstruction. Before implementing the course, teachers need to systematically screen textbooks, online courses, interactive videos, question banks and industry cases, and present knowledge modules suitable for students' independent learning in an online form, such as basic theories and formula derivations; while complex problem solving and application cases are concentratedly explained and practiced in offline classes. The course as a whole focuses on the logical continuity and complementarity of online and offline content to ensure the integrity of knowledge transfer. Especially in mathematics teaching at the vocational undergraduate level, the course content deeply combines theory with professional practice needs, introduces mathematical knowledge through actual engineering cases and workplace problems, and improves students' ability to transform mathematical knowledge into practical skills.

3.4 Reshaping the Teaching Model to Focus on Students

The hybrid teaching approach is restructured around student-led learning pathways. Teachers use intelligent systems to analyze student learning data, assign pre-study tasks, and deliver customized study guides, assignments, and guiding questions to foster inquiry-based thinking. In class, teachers utilize diverse teaching methods such as interactive questioning, real-time feedback, and group collaboration to strengthen teacher-student interaction, actively guiding students to integrate theory with practical scenarios and internalize knowledge. After class, the system dynamically recommends personalized exercises and supplementary resources based on classroom performance and online behavior, helping students address gaps and achieve a continuous learning cycle.

3.5 Reconstructing the Classroom Teaching System with the Help of Intelligence

The heterogeneity problem of large-class teaching of advanced mathematics has been effectively alleviated with the assistance of artificial intelligence. Based on intelligent teaching platforms such as "Cloud Class", teachers can issue multi-level preview tasks before class. The system automatically identifies students' weaknesses and provides additional resource support for students with weak foundations. Students can mark "unmastered" knowledge points during the preview process, which facilitates teachers to adjust classroom content in a targeted manner. In class, teachers focus on common difficulties and explain them. Through classroom quizzes and instant interactions, they understand student feedback and adjust teaching strategies in real time. High-frequency classroom tests,

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data-driven learning monitoring and precise praise mechanisms can effectively stimulate students' willingness to learn independently, realize the transformation from "passive learning" to "active learning", and comprehensively enhance learning motivation.

3.6 Intelligent Integration and Interactive Upgrading of Teaching Resources

Artificial intelligence technology optimizes the integration of teaching resources, achieving seamless integration between online and offline learning. Online learning relies on intelligent learning platforms to provide multi-dimensional resource support, including personalized video lectures, interactive question banks, adaptive tests, etc.; offline classes strengthen high-level thinking training and practical ability improvement, and set up interactive sessions such as case analysis, group discussions, and on-site deductions to further deepen knowledge application. Real-time data feedback provides teachers with a basis for accurate insight into students' learning status and enables dynamic adjustment of teaching plans. At the same time, relying on online discussion areas, group collaboration platforms, and cross-temporal and spatial interactive tools, teachers can guide students to engage in in-depth interactions in multiple scenarios and across time and space before, during, and after class, continuously enhancing learning participation and effectiveness.

4. Results and Discussion

4.1 Experimental Subjects

This study targets the 2025 class of engineering students at a vocational undergraduate college. Two parallel classes, totaling 100 students, are selected, and a controlled experimental approach is employed:

The experimental group (50 students) employs an AI-driven hybrid teaching model (intelligent learning analysis + dynamic resource push + classroom data feedback);

The control group (50 students) employs a conventional teaching model consisting of PowerPoint presentations + blackboard lectures + a fixed question bank.

Both groups receive instruction from the same instructor, and the textbooks and basic course content remain consistent to ensure a fair comparison.

4.2 Experimental Period

The experimental period lasts a full semester (16 weeks), with teaching modules covering core advanced mathematics topics such as limits, derivatives, integrals, series, and multivariate functions.

4.3 Experimental Implementation Process

4.3.1 Teaching Stage Design

Before class:

The experimental group uses the AI platform to publish personalized pre-study tasks and push adaptive learning materials (including videos, questions, and interactive discussions);

The control group receives routine pre-class assignments (a unified preview manual and post-class exercises).

During the class:

The experimental group receives instant feedback on the class through the "Cloud Classroom" platform, combined with intelligent analysis to focus on key points and adjust the pace in real time;

The control group uses traditional blackboard writing and one-way lectures, and the classroom lacks dynamic interaction.

After class:

For the experimental group, the AI system pushes differentiated homework and intensive training based on students' learning trajectories, and regularly generates personalized learning reports;

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The control group completes unified homework.

4.3.2 AI Support Functions

Intelligent learning situation analysis (accuracy, error-prone points analysis)

Personalized question push (special exercises for weak points)

Dynamic resource generation (visual animation, key playback)

Classroom behavior data collection (attendance, interaction frequency)

4.4 Data Analysis Methods

SPSS is used to conduct independent sample t-test and paired sample t-test to verify the significant differences in academic performance and behavioral input between the experimental group and the control group;

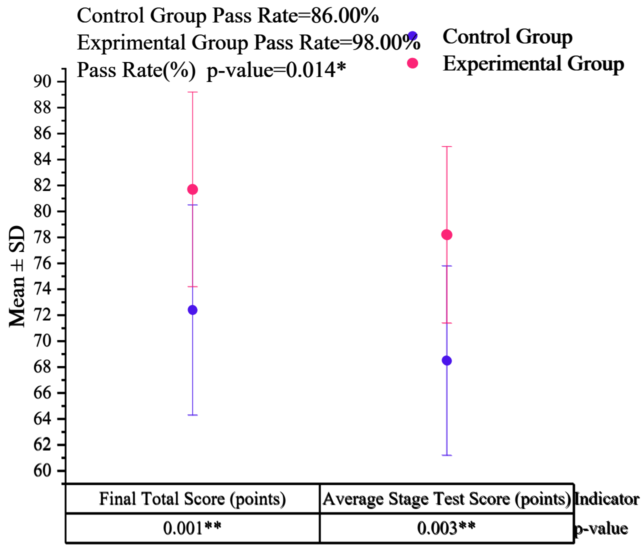

Figure 1 Comparison of learning outcomes

Comparing learning outcomes, the experimental group achieves significantly better overall learning outcomes than the control group. First, taking the final total score, a core evaluation metric, as the experimental group achieves an average score of 81.7, significantly higher than the control group's 72.4 (p=0.001), a highly significant difference. This indicates that AI-powered blended learning significantly and positively impacts final learning outcomes. Second, regarding the average scores on the interim tests, the experimental group also outperforms the control group's average score of 78.2 (p=0.003), with a significant difference indicating the AI-powered blended learning model's sustained superiority in achieving interim learning outcomes. Finally, the pass rate metric show a statistically significant 98.0% for the experimental group and 86.0% for the control group (p=0.014), further validating the effectiveness of this teaching model in reducing students' failure risk, as shown in Figure 1. Overall, AI-powered blended learning demonstrates superiority in improving overall performance, consolidating interim mastery, and ensuring a high pass rate for foundational knowledge. The improvement in the final total score is most pronounced, demonstrating a significant improvement in direct teaching outcomes.

In Figure 2, the experimental group significantly outperforms the control group in all indicators of learning engagement, particularly in pre-class preparation completion rate and class interaction frequency. First, the improvement in pre-class preparation completion rate is most significant, with the experimental group's average completion rate reaching 92.7%, significantly higher than the control group's 61.2%, with a p-value of 0.000, indicating a highly significant difference. This indicates that the personalized pre-class preparation tasks and intelligent reminder mechanism promoted by the AI system significantly enhance students' pre-class learning initiative. Second, the number of class interactions also increases significantly, with the experimental group averaging 9.8 interactions per class, compared to only 3.5 in the control group (p=0.000), a highly significant difference. This suggests that the AI-assisted classroom feedback function effectively stimulates the learning atmosphere. Finally, the completion rate of post-class homework is 95.6% in the experimental group, a

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significant increase from the control group's 79.3% (p=0.002), further demonstrating the positive impact of the AI teaching model on students' post-class learning consolidation. Comprehensive analysis shows that AI blended teaching has produced positive results in stimulating students' enthusiasm for learning throughout the entire process before, during and after class, with the most significant improvements in pre-class preparation and classroom interaction.

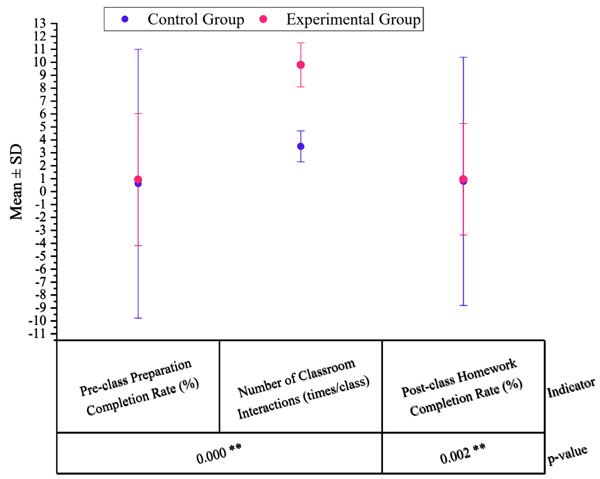

Figure 2 Comparison of learning behavior results

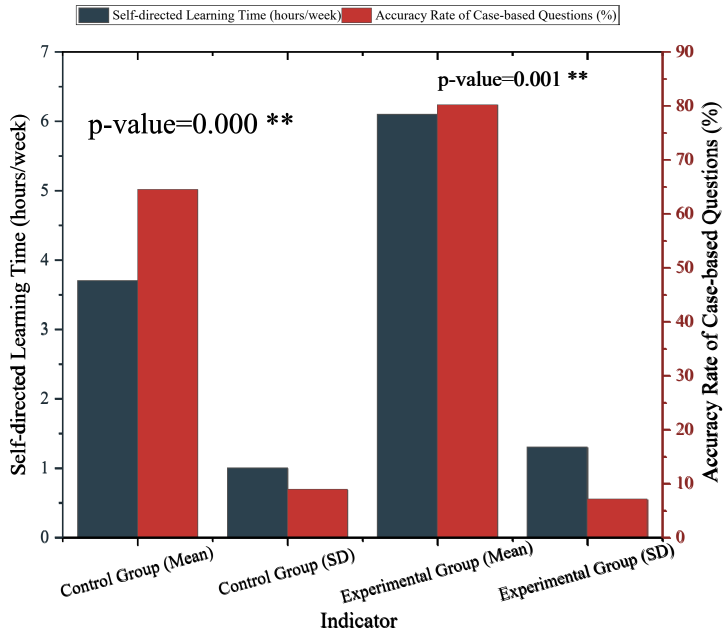

Figure 3 Comparison of learning ability

Comparing learning ability results, AI-powered blended learning has a significant positive impact on improving students' autonomous learning and comprehensive application capabilities. The most significant improvement is in autonomous learning time, with the experimental group averaging 6.1 hours per week, significantly higher than the control group's 3.7 hours (p=0.000), a highly significant difference. This suggests that AI-powered learning tasks and real-time feedback mechanisms effectively guide students to independently manage their study time, significantly enhancing their learning initiative. Secondly, regarding the accuracy rate of case questions, the experimental group achieves an average of 80.2%, a significant increase from the control group's 64.5% (p=0.001), a significant difference. This demonstrates that the AI teaching model helps students effectively transfer theoretical knowledge to real-world situations, improving their ability to solve complex problems, as

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shown in Figure 3.

Table 1 Comparison results of subjective perception

Indicator	Control Group (Mean ± SD)	Experimental Group (Mean ± SD)	p-value
Satisfaction Score (5-point scale)	3.4 ± 0.7	4.5 ± 0.5	0.000 **
AI Teaching Acceptance Rate (“Agree/Strongly Agree” %)	58.00	91.00	0.000 **

In terms of subjective perception, students in the experimental group express significantly higher satisfaction with the teaching model and greater acceptance of AI-assisted teaching than those in the control group. First, regarding satisfaction ratings, the experimental group achieves an average score of 4.5 out of 5, significantly higher than the control group's 3.4, with a p-value of 0.000. This indicates that students are generally satisfied with the AI-driven blended learning experience and recognize the effectiveness of this model. Second, the AI teaching approval indicator shows that 91.0% of students in the experimental group "agreed" or "strongly agreed" that AI teaching is helpful to their learning, far exceeding the control group's 58.0%, a highly significant difference (p=0.000). This result demonstrates that the introduction of AI technology not only improved teaching effectiveness but also strengthened students' acceptance and trust in new teaching methods (see Table 1).

5. Conclusions

This paper addresses the challenges of inefficient resource utilization, insufficient personalization, and low student engagement in vocational undergraduate advanced mathematics instruction. It proposes a hybrid teaching model based on artificial intelligence (AI) big data analysis and a dynamic push mechanism. By constructing a comprehensive teaching system encompassing pre-class intelligent learning analysis, real-time interactive feedback during class, and personalized resource matching after class, the model comprehensively enhances the accuracy and interactivity of the teaching process. Empirical control experiments show that this model significantly outperforms traditional teaching across four dimensions: learning outcomes, learning behaviors, learning abilities, and students' subjective perceptions. The model particularly demonstrates improvements in pre-class preparation completion rates, classroom interaction frequency, self-directed learning engagement, and final grades, validating the practical impact of AI on improving teaching quality and efficiency. While this study demonstrates the positive effects of AI-enabled hybrid teaching, it still has certain limitations, primarily due to the sample size being limited to a single course at a single institution and the need for further refinement of the intelligent algorithm. Future research can further expand its application scenarios across different disciplines and institutions, explore more diverse AI algorithms and deeply personalized learning pathways, and promote the continuous optimization and widespread application of intelligent hybrid teaching models.

References

[1] Chen M F, Chen Y C, Zuo P Y, et al. Design and evaluation of a remote synchronous gamified mathematics teaching activity that integrates multi-representational scaffolding and a mind tool for gamified learning [J]. Education and Information Technologies, 2023, 28(10): 13207-13233.

[2] Wasserman N H, Buchbinder O, Buchholtz N. Making university mathematics matter for secondary teacher preparation [J]. ZDM–Mathematics Education, 2023, 55(4): 719-736.

[3] Shirawia N, Alali R, Wardat Y, et al. Logical mathematical intelligence and its impact on the academic achievement for pre-service math teachers [J]. Journal of Educational and Social Research, 2023, 13(6): 242-257.

[4] Nguyen D T, Tran D. High school mathematics teachers' changes in beliefs and knowledge during lesson study [J]. Journal of Mathematics Teacher Education, 2023, 26(6): 809-834.

[5] Liang B, Ng O L, Chan Y C. Seeing the continuity behind “double discontinuity”: Investigating Hong Kong prospective mathematics teachers’ secondary–tertiary transition [J]. Educational Studies in Mathematics, 2023, 113(1): 107-124.

[6] Fitriati F, Rosli R, Iksan Z H. Enhancing Prospective Mathematics Teachers' Lesson Planning Skills through Lesson Study within School University Partnership Program[J]. Journal on Mathematics Education, 2023, 14(1): 69-84.

[7] Karim S, Zoker E M. Technology in Mathematics Teaching and Learning: An Impact Evaluation in Selected Senior Schools in Masingbi Town [J]. Assyfa Learning Journal, 2023, 1(2): 60-72.

ISSN 2522-6398 Vol. 8, Issue 8: 113-120, DOI: 10.25236/FER.2025.080818

[8] Zbiek R M, Peters S A, Galluzzo B, et al. Secondary mathematics teachers learning to do and teach mathematical modeling: a trajectory [J]. Journal of Mathematics Teacher Education, 2024, 27(1): 55-83.

[9] Aldemir Engin R, Karakuş D, Niess M L. TPACK development model for pre-service mathematics teachers [J]. Education and Information Technologies, 2023, 28(4): 4769-4794.

[10] Pino-Fan L R, Castro W F, Moll V F. A macro tool to characterize and develop key competencies for the mathematics teacher'practice [J]. International Journal of Science and Mathematics Education, 2023, 21(5): 1407-1432.

[11] Weigand H G, Trgalova J, Tabach M. Mathematics teaching, learning, and assessment in the digital age [J]. ZDM–Mathematics Education, 2024, 56(4): 525-541.