Exploring the innovation of teaching mode of secondary school mathematics foundation under the background of digital transformation

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Abstract: Under the background of digital transformation, secondary vocational education is gradually moving towards informatization and intelligence, and the traditional teaching mode of basic mathematics has been difficult to fully adapt to the teaching needs of the new era. This study focuses on the basic teaching of secondary mathematics, analyzes the far-reaching impact of digital transformation on teaching content, teaching methods and teacher-student interaction, explores the specific path of teaching mode innovation, and practically explores the "digitally empowered" higher vocational mathematics curriculum elements of ideology and politics, teaching mode reform, development of digital resources, teachers' digital literacy and other elements of human education. The path and strategy of construction are explored in order to play a nurturing role in the process of digital transformation of vocational education, which will be beneficial to the future research and pilot action of the basic disciplines of vocational colleges and universities. The article proposes a teaching mode optimization scheme based on digital resource development, personalized learning support, and intelligent assessment and feedback, and verifies the significant role of the innovative mode in enhancing teaching effectiveness and learning efficiency by combining with practical cases. This study provides theoretical basis and practical guidance for the reform of basic secondary mathematics teaching, aiming to help secondary education achieve higher quality development in the digital era.

1. Introduction

With the rapid development of information technology, digital transformation has become an important direction for the development of various industries[1]. In the field of education, digital technology is profoundly affecting the teaching mode, learning environment and the development and utilization of educational resources[2]. Secondary vocational education, as an important field of skill-based talent cultivation, has a basic math curriculum that not only provides important support for students' vocational skills learning, but also plays a key role in cultivating the ability of logical thinking and practical problem solving.

Mathematics is the basis of natural science and the source of major technological innovation[2]. As an application course of the mathematics discipline, the mathematics course is the underlying support for the core literacy of vocational education talents, and the traditional teaching mode of secondary mathematics has certain limitations in the design of teaching content, the application of teaching means and the interaction between teachers and students[3]. The lack of diversity in teaching resources makes it difficult to meet students' individualized needs; the relatively single means of teaching assessment fails to comprehensively reflect students' learning[4]. These problems constrain the improvement of the quality of basic secondary mathematics teaching, and it is also difficult to meet the higher requirements of educational innovation in the digital era.

Based on the background of digital transformation, this paper discusses in depth its impact on the basic teaching of intermediate mathematics, analyzes the problems existing in the traditional teaching mode, proposes the innovative path of teaching mode driven by digitalization, and verifies its feasibility and effectiveness through practical cases[5]. The study aims to provide theoretical

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support and practical guidance for secondary mathematics teaching, in order to promote the overall improvement of teaching quality and help secondary education achieve high-quality development in the digital era[6].

2. The Impact of Digital Transformation on the Teaching and Learning of Foundational Mathematics in Secondary Schools

The modern generation of computers, cybernetics, information theory, computational mathematics, game theory and other mathematical branches with strong vitality have greatly enriched the development results of the mathematical discipline, and its integration with cross-disciplinary marginal effect and driving effect is extremely strong[7]. Digital transformation has promoted the comprehensive upgrading of the teaching environment of secondary education. Digital tools represented by intelligent blackboards, online teaching platforms and virtual reality (VR) technology have gradually entered the classroom, creating a more intuitive and vivid learning environment for basic mathematics teaching[8]. This environment not only stimulates students' interest in learning, but also improves teaching efficiency to a large extent, providing a new opportunity for teaching reform, student learning progress:

$$P(t) = P_0 \cdot e^{kt} \tag{1}$$

The application of digital technology has enriched mathematics teaching resources, and teachers can provide students with diversified learning materials in the form of multimedia courseware, online courses and interactive teaching materials. The sharing and convenience of digital resources also enable students to flexibly arrange their study time and carry out independent learning anytime and anywhere, effectively enhancing the flexibility and efficiency of learning. The only way to build the mathematics discipline in vocational colleges and universities is to actively respond to and embrace digital technology, so that it can truly become the front-runner in the cultivation of learners' core literacy with the empowerment of digital technology, and play an irreplaceable leading role in advancing the development of the basic disciplines in vocational colleges and universities[9].

The spread of digital technology has also changed students' learning behaviors and habits. Traditional passive receptive learning is being transformed into self-directed exploratory learning[10]. Students can use intelligent learning systems to select learning content according to their needs and improve their learning effectiveness through personalized learning paths. Digital transformation not only improves students' learning ability, but also cultivates their awareness and ability of independent learning. A large number of new industries and new occupations have emerged, and vocational education, which uses digital technology as a link to connect industries, industries, professions, and employment, is also facing the challenges of rapid industrial restructuring, diversification of student sources, and personalization of learning needs.

Teaching assessment and feedback mechanisms are also significantly optimized with the support of digital technology. With its scientific grasp and intelligent integration of digital technology at the root of the discipline, secondary mathematics has brought into play its advantages in the scientific literacy and sustainable supply of talents in mathematics. The application of intelligent assessment tools and big data analysis technology enables teachers to collect students' learning data in real time and gain a comprehensive understanding of students' learning status[11]. Through accurate data analysis, teachers can provide targeted guidance and feedback, thus supporting students' personalized development more effectively, showed in Figure 1:

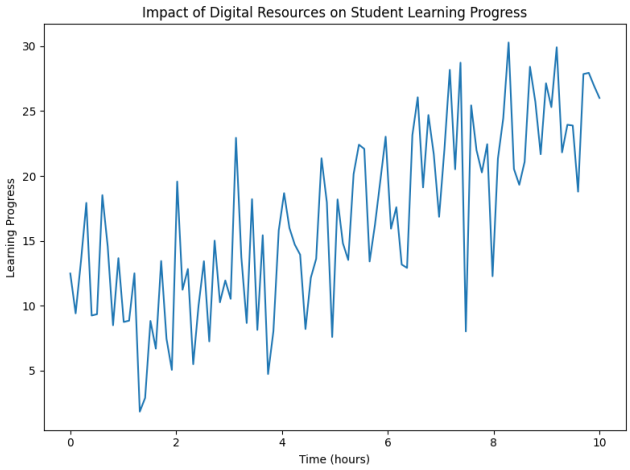

Figure 1 Impact of Digital Resources on Student Learning Progress

3. Innovative Paths to the Teaching Model of Mathematics Fundamentals in Secondary Schools

Under the background of digital transformation, the innovation of the basic teaching mode of secondary mathematics needs to be closely integrated with modern technical means to meet students' individualized learning needs and comprehensively improve the quality of teaching as the goal[12]. The development and application of digital resources, the construction of a personalized learning support system, and the optimization of intelligent assessment and feedback mechanisms can be used to comprehensively promote the change of teaching content, teaching methods and teaching evaluation, so as to realize the transformation of an efficient, flexible and accurate teaching mode. The birth of classical mathematical theories mostly stems from solving practical problems in production and life, and contains profound ideals and beliefs, humanistic spirit, scientific values and moral sentiments and other elements of ideology and politics, and the use of digital technology to create a problematic situation is to restore the theoretical knowledge of classroom teaching to life, and to guide students to follow the path of discovering the problem, exploring the problem, solving the problem and summarizing the law to master mathematical logical thinking, Deductive reasoning ability, endogenous tracing the roots, relentless search for the truth of the scientific spirit, to become a moral, intellectual, physical and aesthetic all-round development of the socialist builders and successors, showed in Figure 2:

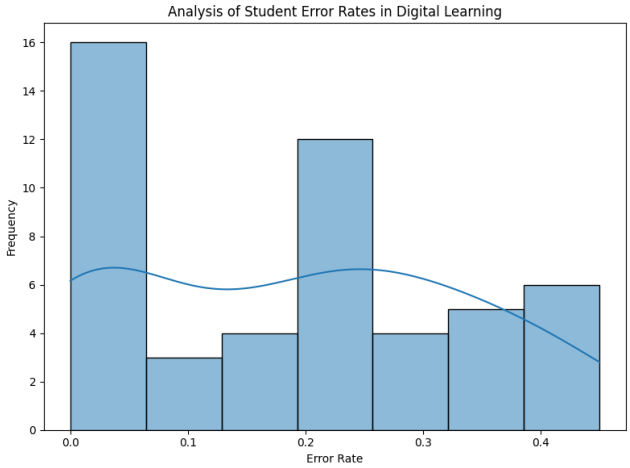

Figure 2 Analysis of Student Error Rates in Digital Learning

3.1 Development and application of digital resources

The development and application of digital resources have injected new vitality into secondary mathematics teaching. The virtual simulation and human-computer interaction digital learning

environment empowered by digital technology, and the digital resources that are "available all the time and can be learned everywhere" have contributed to the realization of situational cognitive learning of profound and abstract mathematical theories, and through the introduction of multimedia technology, teachers can produce dynamic geometric demonstrations, video explanations and interactive courseware and other resources. By introducing multimedia technology, teachers can create dynamic geometric demonstrations, video explanations and interactive courseware. These resources can present abstract mathematical concepts vividly and help students deepen their understanding and enhance their interest in learning. Compared with traditional teaching materials, this approach can attract students' attention and make the learning process more intuitive and efficient, error rate analysis in student responses:

$$E = \frac{\text{Number of Incorrect Responses}}{\text{Total Responses}} \tag{2}$$

The application of online teaching platforms has further enriched students' learning resources. It has accelerated the digital transformation of the traditional teaching methods and parenting mode of the mathematics curriculum, shaping the deep integration of elements such as the knowledge-based, character-oriented curriculum system, teaching mode, and learning space with digital technology. These platforms not only provide a massive library of practice questions, but also are equipped with an instant feedback function to help students find and correct errors in their independent learning. The interactive functions on the platform enable students to communicate with teachers and classmates at any time, forming a favorable learning atmosphere and enhancing learning effects.

The utilization of Open Educational Resources (OER) significantly broadens the possibilities for developing digital resources, empowering educators to create more engaging and effective learning environments. By leveraging high-quality resources from both domestic and international platforms, teachers can tailor and innovate content to align with specific teaching objectives and cater to the diverse learning needs of students. This approach enables the creation of flexible, varied, and dynamic teaching materials that not only enrich the curriculum but also enhance student engagement. Furthermore, the integration of OER reduces the financial burden of resource acquisition, promoting equitable access to quality education and fostering a more inclusive and cost-effective teaching ecosystem.

The application of artificial intelligence (AI) technology in resource development is becoming popular. By analyzing students' learning behavior and data, AI technology can dynamically recommend suitable learning content and practice topics for students, realizing personalized customization of resources. This highly targeted application of resources not only effectively improves learning efficiency, but also provides students with a more personalized learning experience.

3.2 Construction of a personalized learning support system

The construction of personalized learning support system is the key link to promote the innovation of secondary mathematics teaching mode. Student-centered teaching modes such as human-computer collaboration, scenario construction and game experience are constantly emerging, and student-centered learning modes such as online-offline blended learning, virtual reality project-based learning and hierarchical personalized learning are emerging endlessly. By analyzing the learning characteristics and needs of the students, the teachers can formulate a more targeted teaching plan to meet the needs of the students with different learning levels and interests, and maximize the teaching effect. This will maximize the effectiveness of teaching and learning, showed in Figure 3:

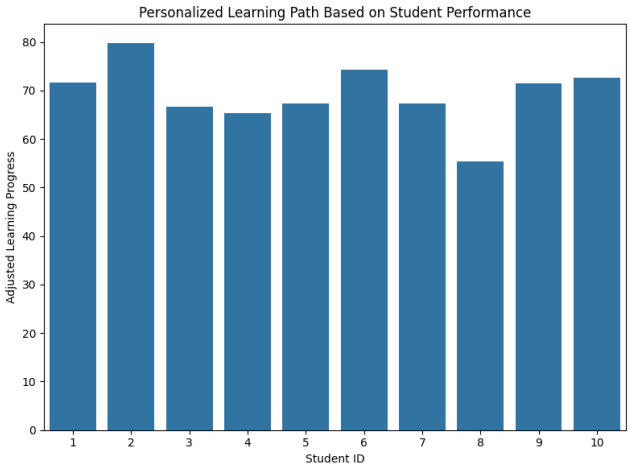

Figure 3 Personalized Learning Path Based on Student Performance

The collection and analysis of learning data serve as the cornerstone for constructing an effective personalized learning support system. With the aid of digital platforms and intelligent tools, teachers can now gather comprehensive data on students' learning activities in real time. This includes critical metrics such as learning progress, error rates, problem-solving time, and engagement levels during different phases of the learning process. These data points not only reflect individual students' performance but also provide a detailed overview of their learning behaviors, strengths, and areas needing improvement. By leveraging this wealth of data, teachers can conduct in-depth analyses to uncover patterns and trends in student learning. For instance, they can identify recurring mistakes, gauge the time required for mastering specific concepts, and evaluate the effectiveness of teaching strategies. These insights lay a solid data foundation for making informed, personalized teaching decisions tailored to each student's unique needs.

Such data-driven approaches enable dynamic adjustments to lesson plans, resource allocation, and teaching methods. This ensures that learning is not only more targeted and efficient but also fosters an engaging and supportive educational environment. Ultimately, this system empowers teachers to enhance both teaching outcomes and student satisfaction in the digital age.Based on data analysis, teachers can design differentiated teaching strategies. For students with weak fundamentals, tiered exercises and focused tutoring are provided; for more capable students, challenging tasks and inquiry-based learning activities are designed. Such a tiered teaching strategy not only improves the accuracy of teaching, but also stimulates students' motivation to learn, so that each student can learn and grow at a pace that suits him or her, personalized learning path adjustment:

$$L_{\text{adjusted}} = L_{\text{base}} + \alpha \cdot \left(P_{\text{target}} - P_{\text{current}}\right) \tag{3}$$

The personalized learning support system also emphasizes the intelligent recommendation of learning resources and teaching tools. Through the introduction of artificial intelligence technology, the teaching system can dynamically recommend learning content and practice topics according to students' learning preferences and knowledge weaknesses. This real-time, dynamic support not only improves learning efficiency, but also significantly enhances students' learning experience, making teaching more scientific and personalized.

3.3 Optimization of digital assessment and feedback mechanisms

The optimization of digital assessment and feedback mechanism is an important means to improve the quality of basic secondary mathematics teaching. Traditional teaching assessment mainly relies on the final examination or a single test, which often fails to fully understand the learning process and comprehensive ability of students. Digital assessment, however, provides teachers with more accurate and comprehensive information about students' performance through real-time data collection and analysis, thus realizing personalized teaching feedback and timely adjustment.

Digital assessment enables continuous tracking of students through a learning management system (LMS) or an online platform, and collects various types of data from students during the learning process, including homework completion, online quiz scores, and interactive engagement. students' learning progress, mastery, and barriers to learning can be comprehensively analyzed. Through in-depth analysis of these data, teachers can have a comprehensive understanding of students' learning progress, mastery, and barriers to learning.

Digital technology can also provide instant feedback. Math courses, as public foundation courses, are the key to students' "stuck" problems. When students complete online tests or assignments, the system can quickly grade them and provide detailed explanations of their mistakes. Through this instant feedback, students can find their own deficiencies and make corrections in time to avoid accumulating mistakes and improve their learning efficiency.

The optimized assessment mechanism is not only limited to a single grade assessment, but also incorporates students' learning process, thinking ability and problem-solving ability into the scope of assessment. Teachers can dynamically adjust their teaching strategies and provide targeted counseling based on the assessment results. Students can also adjust their learning strategies through continuous feedback, thus achieving more personalized and efficient learning results, showed in Figure 4:

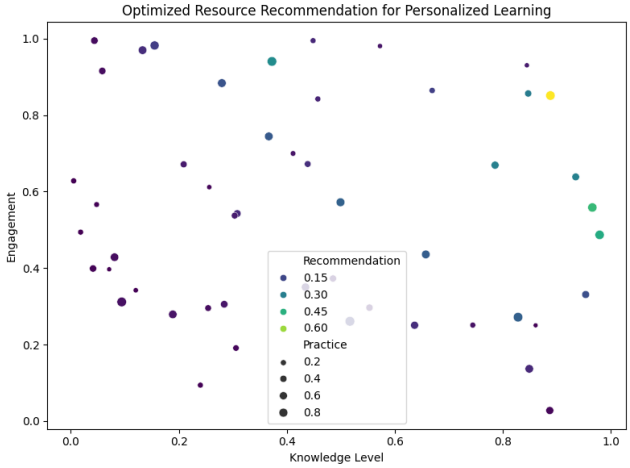

Figure 4 Optimized Resource Recommendation for Personalized Learning

4. Practical Cases and Effectiveness Analysis of Teaching Mode Innovation

Under the background of digital transformation, the innovation of the teaching mode of basic secondary mathematics has been practically applied in some schools and teaching scenarios. Taking a secondary school as an example, it has carried out a series of pilot work on teaching mode innovation by introducing digital resources, constructing a personalized learning support system and optimizing the assessment and feedback mechanism, data-driven feedback:

$$F(t) = \sum_{i=1}^{n} w_i \cdot x_i \tag{4}$$

In terms of the application of digital resources, the school provides rich mathematical learning materials, interactive courseware and online tests by building an online learning platform. Students can independently select learning contents according to their own learning progress for review and consolidation, while teachers can also check students' learning situation in real time through the platform and provide timely guidance. This mode greatly improves students' independent learning ability and learning efficiency, dynamic resource recommendation:

$$R(t) = \beta \cdot A \cdot D \tag{5}$$

The school has designed a personalized learning support system by combining students' learning data. Through intelligent analysis of students' learning behaviors, the platform customizes a personalized learning path for each student. Students are able to access tailor-made learning

resources and practice questions, thus receiving more effective support in their respective learning progress. Students with a weak foundation in math can gradually improve their math skills through additional tutoring and targeted practice,

The school has optimized its teaching assessment and feedback mechanism. With the help of the learning management system and online assessment tools, students can get real-time assessment feedback during the learning process. After each test, the system will provide a detailed analysis based on the students' answers to help them understand where they made mistakes and conduct targeted revision. This instant feedback mechanism significantly improves student learning, avoids the accumulation of errors and promotes continuous improvement, showed in Figure 5:

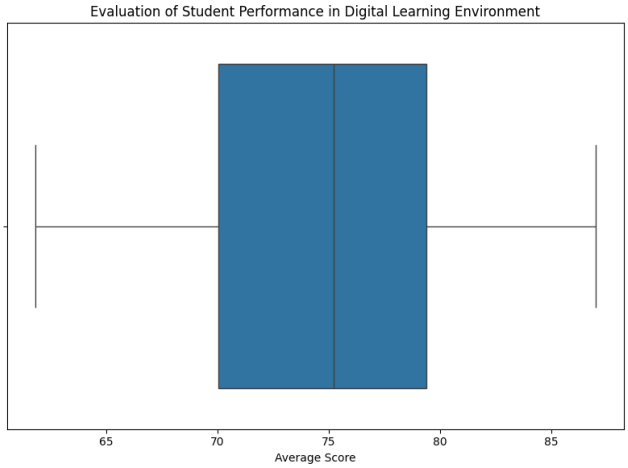

Figure 5 Evaluation of Student Performance in Digital Learning Environment

Through a period of practice, the effectiveness of teaching and learning in the school has been significantly improved. Students' performance in mathematics has generally improved, especially in practical problem solving and logical thinking skills. Students' interest in learning and independent learning ability have also been strengthened, teachers' teaching load has been reduced, and teaching management has become more efficient. There are still some students who are slow to adapt to the new mode during the implementation process. The school plans to strengthen personalized support and training for students in the future to better facilitate the further development and improvement of the teaching mode, overall student performance evaluation:

$$S = \frac{\sum_{i=1}^{n} \text{Score}_i}{n} \tag{6}$$

5. Conclusion

Digital transformation provides brand-new opportunities and challenges for the innovation of the teaching mode of secondary mathematics foundation. Through the introduction of digital resources, the construction of a personalized learning support system and the optimization of the assessment and feedback mechanism, the innovation of the teaching mode not only enhances the learning efficiency and interest of students, but also provides teachers with more teaching support and management tools. In practice, digital transformation helps to break the limitations of the traditional teaching mode and realize the multi-dimensional reform of teaching content, teaching methods and teaching assessment.

Although the digital teaching mode has improved the quality of teaching to a certain extent, it still needs to face the problems of rapid technological updating, varying adaptability of teachers and differences in students' acceptance ability. In the future, the digital transformation of secondary mathematics teaching still needs to be further improved, especially in the popularization of technology application, the strengthening of teaching training and the satisfaction of students' personalized needs, which still need to be continuously optimized and improved.

The innovation of teaching mode in the context of digital transformation has brought far-reaching impact on the basic teaching of secondary mathematics, promoted the overall improvement of

education quality, and shown great potential in personalized learning and intelligent assessment. With the continuous progress of related technology and the depth of educational practice, digital transformation will certainly provide strong support for the high-quality development of secondary education.

References

[1] Lai H M , Chen C P .Factors influencing secondary school teachers' adoption of teaching blogs[J]. Computers & Education, 2011, 56(4):948-960.DOI:10.1016/j.compedu.2010.11.010.

[2] Papavasiliou S , Gorod A , Reaiche C .System of systems engineering governance framework for digital transformation: A case study of an Australian large government agency[J].Systems engineering, 2024, 27(2):267-283.DOI:10.1002/sys.21719.

[3] Nardi E , Steward S . Is Mathematics T.I.R.E.D? A Profile of Quiet Disaffection in the Secondary Mathematics Classroom[J].British Educational Research Journal, 2013, 29(3):345-367. DOI:10.1080/01411920301852.

[4] Aleven V , Mclaren B M , Sewall J .Scaling up programming by demonstration for intelligent tutoring systems development: an open-access website for middle school mathematics learning[J]. IEEE Transactions on Learning Technologies, 2009, 2(2):64-78.DOI:10.1109/tlt.2009.22.

[5] Kinchin G D ,O'Sullivan, Mary.Incidences of student support for and resistance to a curricular innovation in high school physical education[J].Journal of Teaching in Physical Education, 2003, 22(3):245-260. DOI:10.1080/0264041031000071083.

[6] Wright S , Mcneill M , Fry J ,et al.Implications of Student Teachers' Implementation of a Curricular Innovation[J]. Journal of Teaching in Physical Education, 2006, 25(3):310-328. DOI:10.1123/jtpe.25.3.310.

[7] Cowles K V , Strickland D , Rodgers B L .Collaboration for teaching innovation: writing across the curriculum in a school of nursing.[J].Journal of Nursing Education, 2001, 40(8):363-367. DOI:10.1097/00005110-200111000-00011.

[8] Ganggang H G H , Zhiping Y Z Y , Zhongguang F Z F ,et al.With the direction of innovation ability training, Constructing and perfecting experimental teaching demonstration center of Thermal Energy & Power Engineering Specialty[J].South African Journal of Industrial Engineering, 2010, 19(19):137-147. DOI:10.1109/ICETC.2010.5529332.

[9] Ling Y .Research on construction and innovation new foreign language classroom teaching mode based on the "Internet Plus"[J].Journal of Intelligent and Fuzzy Systems, 2021(3):1-6. DOI:10.3233/JIFS-219130.

[10] Wu D , Shen H , Lv Z .An artificial intelligence and multimedia teaching platform based integration path of IPE and IEE in colleges and universities1[J].Journal of Intelligent and Fuzzy Systems, 2020, 40(115):1-10.DOI:10.3233/JIFS-189410.

[11] Klara K , Hou N , Lawman A ,et al.Developing and Implementing a Collaborative Teaching Innovation in Introductory Chemistry from the Perspective of an Undergraduate Student[J].Journal of Chemical Education, 2013, 90(4):401-404.DOI:10.1021/ed300525g.

[12] Na D .Institutional Teaching Innovation under the Demand of Internet + PE[J].Mobile information systems, 2021, 2021(10):9111924.1-9111924.7.DOI:10.1155/2021/9111924.