

Project Design and Educational Reform Achievements of Mathematics under the Guidance of “Integration of Doing, Learning and Teaching”

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[**Abstract**] Aiming at higher vocational students’ confusion about mathematics learning, we draw on the “integration of doing, learning and teaching” to change the closed state of mathematics teaching, serving the lifelong development of students. The theoretical basis is Dewey’s educational theory, Tao Xingzhi’s educational thought, Bandura’s activity theory, Marx’s theory on the comprehensive development of human, and system science. Dewey’s theory emphasizes active work, Tao Xingzhi’s educational thought emphasizes a high degree of integration of students’ practice, teachers’ guidance and their joint learning, Bandura’s theory emphasizes the relative effectiveness of teaching and learning, Marx’s theory of “whole person” emphasizes treating human as a whole, and his theory of systematic science emphasizes the synergistic collaboration between education reform and other aspects. Through the research, we have developed an open classroom, an effective teaching structure, an effective teaching methodology, an effective curriculum carrier for constructing mathematical literacy—mathematical culture and practice activities, enabling the integration of mathematical history with teaching and learning, and the emotional input for mathematical diary.

[**Key words**] educational thought of “integration of doing, learning and teaching”; project design; reform of higher vocational mathematics education; improvement of mathematical literacy; mathematical culture; mathematical history; mathematical diary

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1 Problem presentation and research basis

1.1 Theoretical needs of China’s educational development (educational situation)

China has developed into the world’s second economy, and its basic education has been recognized by some western countries. UK has included Shanghai’s mathematics education as a model for learning, and the internationalization of Chinese education has become a national consensus. However, for a long time, Chinese education has been following the west blindly, copying and reproducing western educational theories. As a result, front-line teachers are in the middle of nowhere, and domestic educators are neglected. Tao Xingzhi is a famous educator in modern China. 100 years ago, he put forward many famous theories on the basis of bold practice, which are great contributions to both traditional Chinese education concepts and the international education

community. At the current solemn moment when Chinese education is going global, it has become an important mission for us teachers to emphasize and draw on his educational ideas and promote the improvement of educational quality and the development of education. Therefore, the research on this topic is very important.

1.2 Needs of school development (necessity)

Suqian Economic Vocational and Technical College stems from Shuyang Normal University, which grows from an ordinary normal university into a model vocational college in Jiangsu Province. After 16 years of exploration, the school has formed a brand, which is influential in Jiangsu and Shuyang. Through the profound research on school tradition, teachers' status and other factors, the school puts moral education, major construction and practical ability as the main directions to promote its sustainable development.

1.3 Needs of student growth and mathematics teaching reality in mathematics courses

Mathematics course is a major cultural foundation course of five-year higher vocational education. Mathematics education can help students form a rational way of thinking, cultivate their ideological sentiment, guide their appreciation of the aesthetic value of science, and cultivate their spirit of scientific innovation. Besides, it can promote students to establish a correct world view, cultivating their ability to propose, analyze and solve problems for understanding mathematics and natural world, the relationship between mathematics and human society, the scientific, cultural, application, and thinking values of mathematics. Training students' rational thinking has a fundamental role, and should be of great significance to their professional course learning and lifelong career development. Mathematics education strives to improve the ability of applying mathematics to solve problems, and is also an important means to implement quality education.

Appreciation of Humanistic Mathematics is an elective course formally opened in our school, which aims to supplement students' cultural knowledge in mathematics, improve their mathematical literacy, and make them appreciate the aesthetics of mathematics based on students' needs of knowledge structure improvement and sustainable development.

1.4 Advantage of utilizable geographical resources

Through literature analysis and investigation practice, we have made a scientific and serious analysis of the external and internal environments of the school. Our school is located in the middle of north Jiangsu traffic, and features unique transportation conditions. It's located in the section of Beijing-Shanghai line, and is an important passage of National Highway 205. Its economic conditions rank top in north Jiangsu Province, and it has been one of the economic and cultural centers of Suqian since ancient times, which features outstanding people, rich cultural heritage and splendid culture. Shuyang is currently one of the top 100 counties in China, and it has a promising development momentum. It is known as "National Hometown of Flower and Tree" and has been a place where writers left immortal poems through ages. There are places like Youth Square, Science and Technology Museum, Railway Station, North Suzhou Car Market, Yuji Ecological Park, Yuji Botanical Garden, and Gymnasium in Shuyang, which are suitable for students' research. Suqian is very rich in natural and human resources, with 2 lakes in total. In conclusion, it can be said that we have unique conditions for developing fine courses. At the same time, our school is National Spark School, National Software Testing Shortage Talent Base, National Cheerleading Demonstration Window, Garden Unit in Jiangsu Province, First Batch of High-level Demonstrative Higher Vocational Colleges in Jiangsu Province, Civilized Unit in Jiangsu Province, Advanced Unit of Moral Education in Jiangsu Province, Best Organization School of Jiangsu Province Innovation Competition, and Provincial Training Base of Numerical Control and Electronics, which has a complete set of software and hardware facilities. The

school's "research-based learning" activities are carried out in a colorful manner, the use of local resources to carry out research-based learning research has laid a solid material foundation for the study of this topic. Students have a strong interest in learning the fine curriculum, and teachers' teaching ability is very strong.

1.5 Research foundation (practicality)

The project group has long had a clear understanding of the dilemma faced by the teaching of mathematics, and has been exploring and thinking about it profoundly. The group had launched "humanistic mathematics" course for several years, attempting to study a few provincial topics for this research and lay a certain foundation. From 2009 to 2023, the elective course "Humanistic Mathematics" and "Mathematical Practical Activity" have been offered several times, which won the Teaching Achievement Award of the Union College and the 16th Philosophy and Social Science Achievement Award of Jiangsu Province in 2021. In the early stage, we have the corresponding work foundation.

2 Research value and connotation

2.1 "Integration of doing, learning and teaching" can change the current "confusing" state of higher vocational mathematics teaching

Currently, due to the quality of students, higher vocational mathematics is in a state of low benefit, which has a negative impact on students' professional learning, ability to improve and lifelong development, but there is a lack of successful cases that can be drawn on and promoted. The research on this topic is enlightening for the reform of higher vocational mathematics curriculum.

2.2 Reform the closed and "island" situation of mathematics curriculum and teaching

Schools are often closed "island", which is not conducive to education and student growth. Based on what students do, many new issues will be brought up; student exchanges and teacher-student interactions encourage students to return to life and make bold discovery, thus promoting the diversification of teaching resources in mathematics, openness of teaching methods, teaching and learning interactions, innovation of teaching and learning evaluation. Besides, they can promote meaningful teaching and learning, promote students' learning, cultivate students' interest in knowledge; expand students' learning space, exercise students' skills; cultivate students' innovation ability.

2.3 Connotation of the research

The main issue of the research is to draw on Tao Xingzhi's thought to solve the dilemma of low student learning effectiveness and asymmetrical teaching. To change the state of low student efficiency of detachment among doing, learning, and teaching, as well as theory teaching and practical teaching through pedagogical reform, the goal of "lay a solid foundation for students' lifelong development" can be achieved. Teachers can teach re-processed text, organize teaching, and make assignments for students to "do" first; let students ask questions, and turn passive learning into active learning; learn to teach, and determine the content and difficulty of teaching through the feedback of students' learning effect, thus realizing students' potential, cultivate their learning ability and improve their overall quality.

3 Main basis of the research

3.1 Theoretical basis

3.1.1 Dewey's core idea of vocational education

Dewey advocates "active homework" and emphasizes the importance of experiments and internships. He believes that vocational education through active work is one of the most effective means of education. Dewey

advocates vocational education through “active work”, which is consistent with his ideas of education and life, school and society, experience and curriculum, and knowledge and action, showing the core idea of “learning by doing” put forward by Dewey in his *Pedagogical Theories*. He also emphasizes the importance of experiments and internships. In Dewey’s view, experiments and internships can better enable students to obtain intuitive understanding in a real scene, leaving a deep impression on them, so as to stimulate their interest in learning.

3.1.2 Tao Xingzhi’s idea of “integration of doing, learning and teaching”

Tao Xingzhi first put forward the educational idea of “integration of doing, learning and teaching”, and then Xu Dechun modified it into “integration of teaching, learning and doing” and practiced it. It is generally believed that the concept of “integration of doing, learning and teaching” is essentially the same as that of “integration of teaching, learning and doing”, the difference only lies in the expression.

Tao Xingzhi believes that there are four key points. First of all, the “integration of doing, learning and teaching” requires that “brain work is based on labor work”. Tao Xingzhi believes that in traditional education, labor workers and brain workers are separated, resulting in two extremes of “field nerd” (labor workers) and “bookworm” (brain workers). Therefore, in China, “the seeds of science cannot grow”. In order to correct this bias, it is necessary to “(1) teach brain workers to do labor work—to teach those who read to do work; (2) teach labor workers to do brain work—to teach those who work to read”. Second, the reason for “integration of doing, learning and teaching” is that “action is the beginning of knowledge”. Tao Xingzhi criticized traditional education for taking reading and listening to lectures as “the beginning of knowledge”, and the only source of knowledge. Practicing this for a long time, students “refused to do, do not dare to do, and finally cannot do, while knowing nothing”. He believes that doing is an important source of knowledge, and the basis of creation, immersion, and hands-on attempts. Third, “integration of doing, learning and teaching” requires “learning before teaching” and “both learning and teaching”. “Learning before teaching” means that “one should teach themselves before teaching others”, or teach others after teaching themselves first. Fourth, “integration of doing, learning and teaching” is also a rejection of injective teaching method.

3.1.3 Bandura’s self-efficacy theory

According to Bandura’s theory, teachers’ teaching efficacy can be divided into two aspects: general educational efficacy and personal teaching efficacy. General educational efficacy refers to teachers’ general views and judgments on issues such as the role of education in students’ development, i. e. , whether teachers believe that education can overcome the negative influences of society, family, and students’ own qualities on students and effectively promote students’ development. This is consistent with the outcome expectations in Bandura’s theory. Teachers’ personal teaching efficacy refers to teachers’ belief that they are able to instruct students effectively and they have the ability to teach students well. This is consistent with the efficacy expectations in Bandura’s theory. Teachers’ sense of instructional efficacy is a key factor in explaining their motivation. It influences teachers’ motivation towards educational work, how hard they work at teaching, and how persistent they are in overcoming difficulties when they encounter them, among other things.

To synthesize the above, this project applies the theory in the five-year higher vocational mathematics course in northern Jiangsu Province to promote effective teaching and enhance the comprehensive quality of students.

3.2 Practical basis

3.2.1 Marxist theory on the comprehensive development of man

The key points are: (1) the comprehensive development of man is relative to the one-sided development of

man, and a comprehensively developed man is a man whose spirit and body, individuality and sociality are all universally, fully and freely developed; (2) the development of modern large-scale industrial production will surely put forward the demand for comprehensive development of man and provide the possibilities of comprehensive development; (3) the combination of education and productive labor is the only method. The theory is the fundamental guiding principle and theoretical basis for the practical activities of the discipline. In this study, this theory guides the whole process of research on this subject and develops in its depth.

3.2.2 Modern system science

System science is a new comprehensive scientific discipline centered on system thinking, synthesizing the contents of multiple disciplines. This theory is the methodological basis of disciplinary moral education. This study uses its broad meaning to show that disciplinary (mathematics) education and vocational education are a system (education) as a whole, and uses the techniques of fuzzy mathematics in system science to construct a classroom evaluation model of the effectiveness of the implementation of disciplinary education reform to promote teaching and research.

4 Research objectives and methods

4.1 Research objectives

The goal of this project is to find the best teaching method to enhance students' interest in mathematics; to explore the idea of "integration of doing, learning and teaching" to change the current state of inefficiency in the specific reform path of higher vocational mathematics, and to emphasize the effectiveness of teaching from theory to practice of bold reforms. The essence of effective teaching is reflected in "doing", "learning", and "teaching". It's reflected in: effectiveness of "doing"—students take the initiative to act; effectiveness of "learning"—students learn to take the initiative to learn, explore, think and ask questions; effectiveness of "teaching"—teachers can teach, is good at teaching, and dare to innovate in teaching methods. Through the implementation of the teaching model, the quality of teaching can be truly improved. Students can be cultivated in their love and capability to seek "true knowledge" in a harmonious environment, significantly improving the quality of mathematics teaching; to promote the professional development of teachers through the educational reform, improving their sense of achievement in teaching, changing the impact of burnout and bottleneck of professional development, and making teachers show themselves and develop themselves.

(1) Constructing an effective education reform path of "integration of doing, learning and teaching" in higher vocational mathematics through practical research;

(2) Promoting effective education reform strategies of "integration of doing, learning and teaching" in higher vocational mathematics through action research.

4.2 Research methods

This topic mainly adopts the methods of literature collection and action research.

(1) Literature research. It's a research method of reviewing, analyzing and organizing the literature so as to find out the essential attributes of things.

This topic collects effective information at home and abroad, learns theories, strengthens theoretical discussion, and points out the direction for practice. Before the declaration of the topic, in the opening of the topic, the research process needs to find successful cases and experiences of mathematics education reform in vocational schools for many times to guide the research of the topic.

(2) Action research. With the goal of solving real and future problems in education and teaching, the method

of problem solving is proposed, effective methods and systems are designed and developed, the effects are evaluated through teaching practice, and improvements are made on a cyclical basis.

In the practice of school-based mathematics curriculum, experience and lessons can be gained through participation in the practice of classroom reform, enabling research in action and action in research. Through the collective and individual practice of subject group, the plan can be put forward, organized and implemented, reflected on the revision, and summarized and evaluated, so that the subject in action can get in-depth and achieve results.

5 Drawing on the results of educational reform formed from Tao Xingzhi's "integration of doing, learning and teaching"

5.1 Try the "open" teaching reform in mathematics classroom

To cope with the shortcomings of the lecture system, the imbalance between fragmented learning and traditional teaching methods, and the mismatch between students' knowledge base and traditional teaching, we have constructed an "open mathematics classroom teaching model": classroom guidance—students' after-school exploration—classroom display of teachers and students to complement each other (the paper "Exploration of Distributed Classroom" in *Higher Vocational Mathematics*, which is published in *Jiangsu Education Research*, July–August 2017, pp. 40–43).

5.2 Try some teaching method reforms

Solve the deficiencies of students' knowledge integration through interdisciplinary curriculum integration and teaching method reform. Drawing on Tao Xingzhi's thoughts, try to open STEAM classrooms for interdisciplinary learning (the paper "Opening STEAM Class Courses to Promote Cross-boundary Learning in Vocational Education", which is published in *Vocational Education Bulletin*, June 2021, pp. 24–26; won the second prize of the province); "Cultivating Innovative Talents in Vocational Education by Drawing on STEAM Thoughts", which is published in the *Journal of Beijing Institute of Politics and Law*, Dec. 2022, pp. 123–126; inter-professional multi-competency cultivation through scientific and technological societies and project collaboration (the paper "Cultivating Innovative Literacy in Inter-professional Collaboration", which is published in the September 2023 issue of "Innovation and Entrepreneurship Theory, Research and Practice", pp. 80–85); and advancing the pedagogical inquiry of flipped classroom through the utilization of Internet technology to improve the quality of teaching and learning (the paper "From 'Internet + Mathematics' to 'Mathematics + Internet' Educational Transformation", which is published in the *Journal of Urumqi Vocational University*, September 2020, pp. 62–65); promoting the improvement of students' thinking ability through the reform of questioning methods (the paper "The Application of 'Question Chain Guided Independent Inquiry Mode' in Higher Vocational Mathematics", which is published in *Mathematics Learning and Research*, January 2022, pp. 31–32; "Cultivating Artisan Spirit through Artistic Inculcation", which is published in *Innovative and Entrepreneurial Theory Research and Practice*, February 2020, Issue 3, pp. 63–65).

5.3 Form an effective structure of higher vocational classroom

From the practical point of view, we conceptualize new 10 structural modes of the classroom to attract students and make them participate actively, and change the status quo of stagnation in the classroom. Several years of practice has achieved some results. The main effective modes are speech-evaluation mode, dream-inspiration mode, appreciation-reflection mode, filial piety-promotion mode, "story-guidance" mode, game-exploration mode, case-task mode, information integration-problem solving mode, project course-professional course

cooperation mode, and visit-learning mode. Through teaching practice, it is known that the root of effective teaching is that teaching can resonate with teachers and students (the paper “Tao Xingzhi’s Educational Thought and Higher Vocational Mathematics Teaching and Reform” was published in the May 2016 issue of Life Education, pp. 17-19).

5.4 Formation of several teaching reform achievements

The main achievements are Higher Vocational Mathematics Reform Program in Suqian Economic Vocational and Technical College, Research Report, Teachers’ Readings on Mathematics Reform, Compilation of Adaptive Teaching Plans for Mathematics Curriculum, Selection of Mathematics Lesson Plans Embodying the Three-Dimensional Teaching Objectives, Standards and Implementation Rules for Humanistic Mathematics Appreciation, Selection of Teachers’ Papers on Mathematics Reform, and Selection of Student Activity Cases in Mathematics Reform, which are available for teachers’ instructional references.

5.5 Improve the effective curriculum carrier for cultivating students’ core literacy—curriculum of humanistic mathematics and practical activities

Cultivate core literacy in the practice of mathematical culture. Culture is a social factor that affects the creativity of design, and the British mathematician Bacon said, “If a man is not dedicated in his mind, he’d better study mathematics; for in the proofs of mathematics, if he is not dedicated in his spirit, he must do it all over again”. The research has been implemented in the early stage of the mathematical culture and mathematical practice courses, and obtained the teaching achievement award of the United College in 2019 and 2021 respectively. In 2022, the research completed the construction of school’s fine courses, and won the provincial commendation. It continues to improve, optimize the implementation of the curriculum, and form a number of results published or awarded.

5.5.1 Carry out practical activities to learn and improve students’ ability to explore and discover

In the specific practice of mathematical learning, attention should be paid to guiding students to focus on the characteristics of mathematics discipline, concepts and discursive thinking. Through solving more discursive problems, or through analyzing typical errors (including those in some mathematics teaching aids), students can gradually develop the character of independent thinking and defying authority, and cultivate the scientific and critical nature of their thinking. To improve the form of teaching and learning activities of mathematical cultural practice activities, efforts should be made to explore the cultural education function of mathematics (series of results: “The Structure of Mathematical Practice Activities” was published in the November 2020 issue of Jiangsu Education, and won the first prize of the Provincial Society of Education in 2016; “Examining Three-Dimensional Objectives and Enhancing Mathematical Literacy” was an award-winning work in 2019 and 2021 respectively; “Implementing Moral Education in Practical Activities Action Research on Objectives” won the second prize of the province in 2022; a number of cases of moral education teaching in mathematics are shown in Annex IX).

5.5.2 Collect cases of mathematical applications outside the classroom

Instruct students to work in small groups (of course, they can also study independently) to choose appropriate topics from natural and social phenomena they are familiar with, as well as from their lives, learning and other activities. And study them with mathematical methods, so that students can ask questions—collect materials—study and refine—analyze and investigate (including the necessary experimental confirmation)—and form results. In the process of research, students will experience both the hard work of scientific research and the joy of obtaining results. (A series of results: “The Practice of Integrating Mathematical Core Literacy into Curriculum and Culture

under the Perspective of Quality Education” was published in the Journal of Qinghai Normal University, Issue 4, 2021, and “Analysis of Open Mathematics Classroom Mode in Higher Vocational Institutions” was published in the Journal of Guangdong Institute of Technology, Issue 4, 2021, which won the 1st and 2nd prizes, respectively, in the province of 2020–2021).

6 Citing the resources of mathematical history to promote students’ independent investigation of mathematical practice

Mathematical history can promote students’ hands-on inquiry operations, especially the inquiry and thinking methods of historical mathematicians, and guide them to deeply investigate mathematical problems, life problems, production problems, and scientific problems, and this role is more obvious. (The research result paper Wu Wenjun’s “Contribution and its Promotion to Mathematical Development” was published in Guangxi Normal University Journal, No. 6, 2022).

7 Cultivate students’ emotion of being close to mathematics and train their hands-on ability through mathematical diary

Students in vocational colleges have ability deficiencies and often lack effective teaching countermeasures. We have found a way to cultivate students’ comprehensive abilities in our years of exploration—mathematical diary. Mathematical diary has proved to be a way to guide students to reflect and refine their mathematical thinking, and promote the cultivation of their core literacy. It is worthwhile to promote such a good teaching countermeasure in mathematics (the result “Practicing Tao Xingzhi’s ‘Six Emancipation’ Thoughts in Mathematical Practical Activities” was published in National Journal of “Life Education” in 2018–March issue).

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