

# A Practical Study on Enhancing Students' Mathematical Literacy by “Integration of Doing, Learning and Teaching”

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[ **Abstract** ] In face of the mathematical foundation of students in higher vocational colleges, Tao Xingzhi's educational thought is of great guiding significance. “Integration of doing, learning and teaching” is not only the theoretical basis of Tao Xingzhi's educational thought, but also his methodology and action guideline. Tao Xingzhi emphasizes the unity of knowledge and action, among which action is greater than knowledge. This concept is isomorphic with the mathematical culture curriculum. Drawing on the idea of “integration of doing, learning and teaching”, we explore the math culture curriculum and expand the four forms of teaching and learning in math culture: theoretical training, practical exploration, research – based learning, and reflective learning. In the implementation of the school-based curriculum, local teaching resources should be fully exploited, constructing the mathematics teaching mode of “Integration of doing, learning and teaching”, effective teaching methods and classroom evaluation algorithms, ensuring the relevance of vocational education and improving mathematical literacy.

[ **Key words** ] “integration of doing, learning and teaching”; higher vocational mathematics; mathematical literacy; mathematical culture nurturing; teaching mode

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## 1 Problem presentation

To cultivate students' practical ability, quality education should be comprehensively implemented, which is the consensus at the national decision – making level. China proposes “comprehensively promoting quality education” in order to vigorously cultivate talents with innovative spirit and ability. Through exploration and practice, students learn and master new knowledge, enrich and improve their quality and ability. Therefore, how to improve students' creative thinking and hands-on ability is a problem worth exploring, and we need to work hard to solve the problem as soon as possible.

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.

Tao Xingzhi's “integration of doing, learning and teaching” focuses on cultivating students' self-study and

problem-solving ability, which is inherently consistent with quality education. The targeting problem of our declaration of the provincial research project 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.

## **2 Current status of research on related issues**

Tao Xingzhi put forward the theory of "integration of doing, learning and teaching" 90 years ago. Since then, it has been studied and practiced in domestic education. Similarly, there are theories as the integration of teaching and learning (model), learning and teaching, teaching and doing (teaching model), learning by doing (Dewey), doing by learning and so on. Educators at home and abroad attach great importance to the significance of "doing by learning" based on constructivist theory. In recent years, researchers and front-line teachers have been conducting comparative research and practice on "integration of doing, learning and teaching" from the aspects of connotation, background and goal, theoretical foundation, implementation mode, curriculum implementation, teaching reform, teaching mode, and so on. Their aim is to have a more in-depth understanding of the current vocational education reform and effective teaching.

Regarding the origin of "integration of doing, learning and teaching" and its relative teaching methods, it is recognized that the earliest origin is from Dewey's core idea of vocational education. The model "integration of doing, learning and teaching" is proposed and practiced by Tao Xingzhi, Chen Heqin, Xu Dechun and a group of other scholars after repeated debates. In 2001, with the advocacy of children's science education in international education community, China also began to practice the "doing by learning" model, which is different from what we proposed. The model "integration of doing, learning and teaching" is derived from "integration of teaching, learning and doing" model, because it incorporates "doing" into the model that is the most missing element of vocational education. Although the "integration of teaching, learning and doing" model incorporates the most missing element of vocational education into the model and realizes the fundamental change and transformation of the teaching mode, it is still the model of "teaching" first, "learning" second and "doing" third. However, it is still the order of "teaching", then "learning" and "doing". In fact, it still puts the practice of "doing" in the subordinate position of theoretical teaching and plays the auxiliary role of confirming, deepening the understanding, which is not in full conformity with the characteristics and laws of vocational education. The nature of discipline-based teaching has not been fundamentally reversed or corrected.

Zhang Jian (2014) constructed the professional curriculum model of "integration of doing, learning and teaching", and proposed five integration strategies: integration of curriculum environment—integrating workshop with classroom, integration of curriculum content—integrating teaching with work process, integration of curriculum organization—integrating cognitive law with ability generation law, integration of curriculum implementation—integrating theoretical learning with practical operation, and integration of curriculum evaluation—integrating sample with learning attitude evaluation. Currently, vocational education must innovate and reconstruct the above model, adjusting it to "doing", "learning" and then "teaching", i. e., "integration of doing, learning and teaching". This is the only way to truly conform to the fundamental law of vocational education. In this regard, Ma Chengrong, Liu Jun, Liao Biwen and others advocate that the word "doing" should take precedence, "learning" throughout the process, and "teaching" according to opportunities.

Many researchers believe that the teaching model of "integration of doing, learning and teaching" has an all-round adaptability. Whether in primary schools, secondary schools, vocational institutions or even universities, it can be promoted and adopted. Xu Guoqing believes that "doing by learning" is the specific embodiment of the idea

of “active homework training”, but also the only appropriate training for the implementation of vocational education. Zhang Yan believes that “learning by doing” integrates science education and vocational education in terms of vocational content, and internalizes vocational education by combining it with general education, so as to cultivate the ability of students to restructure and transform “their own experience” in life. Through the teaching method of “learning by doing”, production practice is combined with the teaching of knowledge, so as to help students acquire the necessary knowledge and skills for professional life. Shi Shuli believes that in the implementation of vocational education, “learning by doing” is actually a method of organizing knowledge, that is, organizing and implementing teaching and learning through vocational activities, so that students can seek direct experience in the activities.

Regarding the ways and means to promote the implementation of “learning by doing” in professional courses of higher vocational education, many people believe that a series of “doing in learning, learning in doing” practical teaching reforms aim at realizing the perception of students’ vocational behaviors, cognition of vocational behavior and development of vocational ability. And there are various methods and approaches in the implementation of specific teaching, which are mainly the reform of practical teaching methods, the reform of practical teaching curriculum system and the organization of teachers.

Zhang Xin has studied the structure of teaching materials of “doing by learning” in vocational education, and believes that teaching material, as an important object in teaching activities, bears multiple tasks such as ideology and moral character cultivation, human experience inheritance, psychological structure construction, interest and motivation development, etc., which are difficult to design. In recent years, along with the deepening of the research on teaching materials for secondary schools, a large number of teaching materials for secondary schools have emerged. But behind this unprecedented prosperity, there are many problems in teaching materials for secondary schools. The construction of teaching materials needs to be standardized, and the structure of teaching materials needs to be classified and sorted out.

Regarding the implementation of “doing by learning” teaching reform in higher vocational education, the researcher believes that in the exploration of the inevitable difficulties and problems, college educators should have enough courage and unremitting perseverance. To strengthen the exchange between college teachers, the cooperation mechanisms between colleges and enterprises should be constructed. Only in this way, can truly ensure that the teaching reform of colleges continue to deepen and achieve success.

Tu Ping, Wang Jiaoguo and Zheng Yingjuan studied the implementation of this method of the process of misunderstanding, in order to successfully implement “learning by doing”. Teachers should change their concepts and improve the quality. Writing “narrative stories” and “case studies” in conjunction with the implementation of “learning by doing” is a very effective way to improve the quality of teachers as soon as possible. By “narrative stories” and “case studies”, teachers will gain the same experience in “learning by doing” process, will have a deeper understanding of the concept of “learning by doing” and will be more and more in place in the implementation of “learning by doing”, so that they can grow together with “learning by doing”.

Generally speaking, the recent academic research on this educational idea has made a lot of achievements, but the following problems still cannot be ignored: First, the phenomenon of picking up the ideas of others and repeating the research is relatively common. Second, there are fewer in-depth studies. A considerable number of papers only stay at the level of simple introduction of theoretical knowledge, lacking profound connotation and practical value of its ideas, especially the theoretical basis for the establishment of its educational ideas. Third, the research method is relatively single. Comparative research method has not yet attracted enough attention. Although in recent years there has been master’s thesis on the comparative study of Tao Xingzhi and Dewey, and Tao Xingzhi Vocational Education thought, the research still needs to be further in-depth. Fourth, the research perspective is relatively narrow. Tao Xingzhi’s educational thought is based on philosophy, psychology, sociology and even economics and other multidisciplinary foundations. However, few articles analyzing his educational thought from multiple perspectives. Fifth, there is a lack of deep critical research. Tao Xingzhi’s educational thought has

operational deficiencies, and its limitations should be analyzed so that “borrowing the stone of other mountains to attack jade”. Sixth, there is a lack of applied research on the application of the teaching idea of “integration of doing, learning and teaching” in the mathematics curriculum of higher vocational schools. Therefore, this study has important theoretical value and practical space. From the perspective of five-year vocational schools, there is no precedent, which leaves a lot of space for the study of this topic, which is also the value and significance of this study.

### **3 Theoretical results obtained from the research**

#### **3.1 The pursuit of Tao Xingzhi’s educational thought is still of great value in contemporary times**

In the new era, studying “integration of doing, learning and teaching” can explore its theoretical value, carry forward Tao Xingzhi’s thought, improve the quality of teaching in higher vocational education, and create a gap in mathematics teaching. “Integration of doing, learning and teaching” is the methodology of the famous educator Tao Xingzhi’s theory of life education, as well as his pedagogical theory, or known as the teaching mode. It has fundamentally changed the methodology of traditional education and discarded the shortcomings of traditional and westernized education. 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. (the paper “Tao Xingzhi’s Educational Thoughts and Reform of Higher Vocational Mathematics Teaching” was published in Journal of Higher Education, April 2020). There are a few points to note:

- (1) Tao Xingzhi’s educational thought is carried out for vocational education initially, so vocational education sector need to pay attention to it and fully learn from it;
- (2) Tao Xingzhi’s educational thought has strong vitality, which is not outdated at present and will never be outdated;
- (3) Tao Xingzhi’s educational thought is profound and worthy of our attentive research and in-depth study.

#### **3.2 Tao Xingzhi’s educational thought is isomorphic with the education reform of higher vocational mathematics cultural and practical activities ( drawing on Tao Xingzhi’s social and educational thought to build the framework of mathematics practice courses)**

Tao Xingzhi’s educational thought and mathematical practice activities together reveal the current issue of “student development core literacy”, which is particularly concerned by the education sector. Tao Xingzhi’s educational theory mainly includes three aspects; life is education, society is school, and teaching and doing are in unity. He advocated that education should be linked to real life, opposed to pure reading, and emphasized the cultivation of children’s creativity and independent working ability. The theory of life education is the main line and important cornerstone of Tao Xingzhi’s educational thought, and later attributes the characteristics of life education to several aspects of life, action, popular, forward, world, and historical. Life education is the education that strives for the liberation of the masses and the liberation of the nation. (The paper “Core Literacy: Commonality of Tao Xingzhi’s Educational Thought and Higher Education Mathematics Practical Activities” in Mathematics Learning and Research, 2022, April issue, pp. 19-20 won a provincial awarded. The paper “Promoting the Integration of the ‘Three Cores’ in Mathematics Education” is published in Mathematics Learning and Research, June 2021 issue, pp. 2-5)

Cultivating students’ core literacy is the consensus of countries all over the world. China announced the

national consensus of “Lifelong Learning” in 2014, and released the “Core Literacy for China’s Students” in 2016, which is inherently consistent with Tao Xingzhi’s cultivation of children’s life force. Through long-term theoretical exploration and practical research, the group researched the mathematics practice teaching resources in the network environment with the “integration of doing, learning and teaching” model, constructed a mathematics practical training platform, improved students’ mathematics and information technology literacy, and utilized more resources to promote the strategic conception of mathematical understanding, and constructed a mathematical practice base and resource system inside and outside of the school, which is in line with the national consensus of “China’s core qualities of student development”, according to the choice of teaching content and supporting pedagogies in the subject of mathematics.

The group constructed the following curriculum system of mathematical culture and practical activities, and achieved satisfactory results.

Classification	Program	Details
Practical Activity Course in Mathematics	Storytelling	Mathematical Stories, Students’ Forum
		Movie about Mathematician’s Life
	Audiovisual Appreciation	Mathematical Appreciation, Mathematical Aesthetics
		Creating Three-dimensional Geometric Figure
	Operation	Mathematical Games, Mathematical Tours
		Fun Mathematics, Sudoku
Practical Activity Course in Integrated Mathematics	Appreciation of Humanistic Mathematics	Appreciation of Humanistic Mathematics
	Mathematical Software and Mathematical Experiments	Introduction to Mathematical Software and Mathematical Labs
	Information Technology and Mathematics Integration Practices	Integration of Educational Technology and Mathematics Teaching
	Mathematics Lectures	Application Value of Mathematics, Fascination of Mathematics
	Investigative Research in Mathematics	Mathematical Measurement, Mathematical Survey Research, Mathematical Statistical Analysis
	Mathematics Research Study	Selected Cases of Research Studies
Open Practical Activity Course in Mathematics	Community Mathematics Practical Activity	Mathematical Creativity and Invention Practical Activity Course
	The Communist Youth League infiltrates the Curriculum of Related Mathematical Activities	Expanding the Hands-on Mathematical Activities Curriculum
	Social Service Mathematical Activity	Community Service Projects and Math Literacy Training Program

Comparison of Tao Xingzhi's ideas on life education and practical activities in mathematics reveals that the two have intrinsic commonality, which is mainly reflected in four aspects: consistency with the international education requirements of the "four learning" (learning to know, learning to work together, learning to live together, learning to conduct oneself), consistency with the requirements of students' core qualities, consistency with the cultivation of students' ability to develop sustainably, and consistency with the goals of social core values. The essence is to improve students' core literacy (the paper "The Structure of the Five-year Higher Vocational Mathematics Practical Activity Class" was published in Jiangsu Education, November 2020, and was praised by education assessment experts and by the reader Zhang Hua, whose review was published in the title page of the January 2021 issue of Jiangsu Education and won the first prize in the province).

**3.3 Drawing on Tao Xingzhi's thoughts on life to construct the school-based quality course "Appreciation of Humanistic Mathematics" ( its content framework and segmented implementation methods are as follows )**

Grade	Basic Content	Educational Purpose	Main Teaching Materials	Semester Hours	Main Teaching Forms	Note
1	Fun Mathematical Stories and Knowledge	Infiltrate Mathematical Ideas and Cultivate Scientific Attitudes	Fun Mathematical Reading	4	Events, Lectures	The content of mathematics history is the vehicle and should be used throughout all grades.
2	Mathematics History, Stories of Mathematicians	Infiltrate Mathematical Methods and Train in the Scientific Method	Mathematical Story	8	Research Activities, Surveys	
3	Mathematical Aesthetics, Mathematical Problems	Infiltrate Mathematical spirit and Cultivate Science Spirit	Prophet of Mathematics	10	Lectures, Research	
4	Mathematical Culture and Philosophy	Appreciate the Cultural Taste of Mathematics, Appreciate the Interaction between Social Culture and Mathematical Culture, and to Infiltrate Mathematical Ideas and Methods.	Divine Comedy of Mathematics	12	Optional Course	
5	Mathematical Modeling and Research Learning	Combine Internships and Apprenticeships to Infiltrate Mathematical Modeling, Expand Mathematical Applications and Enhance Mathematical Literacy	Demonstrate How to Collect Information by Counting Histories	10	Open Research, Research Studies	Motorized, can be compressed to other grades

( "Tao Xingzhi Educational Thought and Reform of Higher Vocational Mathematics Teaching" , in Life Education, May 2016 issue, pp. 7-11; won provincial award)

### 3.4 Drawing on the idea of life education to expand the forms of practical activities in mathematical culture

According to the needs and possibilities of the school-based curriculum, four forms of humanistic mathematical activities are conceived.

#### 3.4.1 Lectures for optional courses

Launched lectures include applied value of mathematics, application of mathematics in various professions, mathematics in ancient china, computers and mathematics, relationship between culture and mathematics, music and mathematics, beauty in mathematics, art and mathematics, mathematics and literature, mathematics and life, mathematics and other sciences, mathematicians, mathematical stories, mathematical culture, mathematical history, mathematical game studies, mathematical thought appreciation, and mathematical method analysis (The paper “Implications of Mathematical Practical Activity Courses for the Inspiration of Mathematics Teaching” is published in the December 2023 issue of Mathematics Learning and Research, pp. 37-38).

#### 3.4.2 Research-based study activities of Mathematics

Launched activities include a survey of rural measurement, mathematics in accounting, standards of digital poetry, mathematics in painting, mathematics in paper-cutting, mathematical origins of human society, mathematical applications around us, the culture of mathematical symbols, the contributions of Chinese mathematicians, ancient Chinese mathematics, ancient Chinese algorithms, culture in numbers, mathematics and cross-cultural understanding, and mathematics and the development of human society (The paper “Building on the Scientific and Humanistic Practicing Core Values in Integration” is published in the Journal of Guangdong Transportation Vocational and Technical College, August 2023, pp. 112-117).

#### 3.4.3 Study activities of Mathematics application and design

Launched activities include the study of mathematical software Geometer Sketchpad, the study of mathematical software Mathmatics, the design of campus greening, the activity of making geometric teaching aids, the design of campus websites, the study of passwords, the study of campus surveying, the study of mortgage and loans (The paper “Effective Practices of Higher Vocational Mathematics in Practicing the Educational Ideology of Tao Xingzhi” is published in the September issue of Educational Practices and Research, 2021, pp. 65-70).

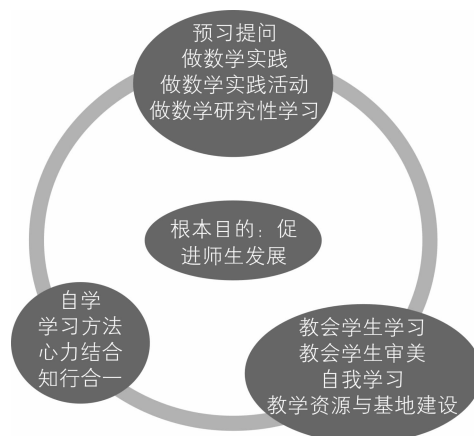
#### 3.4.4 Experiential learning activities based on social investigation

Launched activities include middle school students' visit to National Museum of Codes (the only one in China), supermarket statistics, a survey of the car market in northern Suzhou, a survey of the Shuyang Railway Station, a survey of Shuyang's flowers and trees, statistics of Shuyang's neighborhoods, a visit to a nursing home, a survey of students' hobbies, a study of the functions of cell phones, a study of the functions of e-mail, and a study of the functions of Weibo (The paper “Practicing Tao Xingzhi's ‘Six Emancipation’ Thoughts in Practical Mathematics” is published in the March 2018 issue of Life Education, pp. 75-79).

## 4 Teaching results obtained from the practice

### 4.1 Constructing an effective scheme of “integration of doing, learning and teaching” for higher vocational mathematics through research

To change the state of low student efficiency of detachment among doing, learning, and teaching, as well as theory teaching and practical teaching, 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



Scheme of “integration of doing, learning and teaching” in Mathematical Teaching

improve their overall quality.

#### **4.2 Put forward the operation mode and implementation plan of mathematics course**

Constructing higher vocational mathematics teaching mode of “integration of doing, learning and teaching”—“hands-on attempt to do—questioning the problem of learning—teachers and students teach each other” mode based on the reality: pre-course investigation (or create a living problem situation; students try to do)—propose mathematical history and problems (mathematics comes from life, refining life problems into mathematical problems; teachers correct and give positive demonstrations)—guide thinking and analyze the solution of the problem (students practice again)—summarize and discuss the ideas and methods involving the problems, and train the spirit and value of mathematics (mathematics is applied to life; the teacher corrects and summarizes again). The results show that: students’ learning motivation is high, their spirit is uplifted, their interest in learning is well cultivated, the living of mathematics creates a good learning platform for students, makes them good at observing the living world around them, and cultivates their mathematical modeling and problem consciousness (The paper “Mathematical Activities to Cultivate Core Competencies under the Perspective of the ‘Six Emancipations’” is published in the January 2020 issue of Jiangsu Education Research, pp. 79–81)

#### **4.3 Obtained effective implementation plans for “Integration of doing, learning and teaching” through exploration**

The essence of effective teaching is reflected in the effectiveness of “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.

#### **4.4 Constructing classroom evaluation algorithms for practice activities of mathematical culture**

The evaluation program of the effect of “integration of doing, learning and teaching” in higher vocational education based on effective teaching should be researched; construct the evaluation system of the implementation effect of “integration of doing, learning and teaching”, explore strategies for the use of “integration of doing, learning and teaching” in the classroom, and draw on the new algorithm of mathematics to try to evaluate the classroom teaching of practice activities of mathematical culture (The paper “The Application of the Linkage Number Mean Score Theorem in Fuzzy Group Decision-making” (teaching evaluation mode) is published in the November 2017 issue of Practice and Understanding of Mathematics (Chinese core), pp. 10–17; in January 2019, it won Municipal Award for Outstanding Achievements in Natural Science).

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