Fundamental Focuses of Chinese Mathematics Education: Characteristics of Mathematics Teaching in China

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Recently, Chinese scholars have focused on the thinking, analysis and summary of Chinese mathematics education, and have achieved rich fruitful research. This paper presents a discussion about how Chinese Mathematics Education gets the basics right.

Key words: Chinese mathematics education, reform.

Introduction

The U.S. magazine TIME (12th November, 2009) published an article entitled *Five things the U.S. can learn from China*. The second of the five is education. This article mentioned that William McCahill, a former deputy chief of mission in the U.S. embassy in Beijing, says that "Fundamentally, they are getting the basics right, particularly in math and science. We need to do the same. Their kids are often ahead of ours."

This is the most sincere and authorized assessment since the re-recognition of Chinese mathematics education in the world.

Actually, the emphasis on building a solid foundation for mathematics education has a deep root in traditional Chinese culture. Chinese mathematics education has quite a number of traditions, among which is that there is no lack of great achievements that can be inherited and expanded. Some even have the possibility of creative development, yet there are still some drawbacks violating science.

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The Fundamental Guiding Principles of Mathematics Education in China

Strengthen the Idea of "Two Basics" Teaching

The "two basics" in mathematics refer to basic knowledge and basic skills. The "two basics" teaching principle in mathematics aims to strengthen the basic knowledge and basic skills so as to lay a solid foundation for students' further study and development.

The "two basics" teaching principle has historical roots. It originated from the most simple and unadorned thought of mankind, that is, that a good foundation is essential for the construction of a building.

This principle was written into the Chinese Mathematics Syllabus in 1963. Today, the idea of "two basics" teaching is deeply rooted in the minds of Chinese mathematics teachers. They devote much effort in carrying out this idea constantly in both their thinking and behavior.

Develop Mathematics Thinking Skills

It is well-accepted among Chinese teachers that mathematics is a science of thinking. Developing the thinking of human beings is the greatest value of mathematics. As for mathematics education, developing students' mathematical thinking is an important objective of mathematics teaching. A significant indicator is the development of students' mathematical thinking skills.

The 1963 syllabus put forward the idea of "three basic mathematical abilities." It requires developing students' mathematics thinking skills in the process of mathematics teaching. Hence, developing thinking and cultivating ability not only become the common awareness of mathematics teachers but also is extensively used in the practice of mathematics teaching.

Preserve Heuristic Mathematics Teaching

Heuristic teaching was proposed by Confucius 2,500 years ago. The essence of heuristic teaching is "do not intervene before students have made an effort to understand, before students have made an effort to express themselves."

It is the treasure of an educational idea in China and the most fundamental guiding principle of teaching. It has profound, far-reaching influence on Chinese education.

After thousands years, this idea is deeply rooted in the mind of Chinese teachers. Heuristic is considered as the basic skill of teaching. A teacher may be considered as incompetent if he/she does not know how to apply heuristic concepts.

Respecting the Mathematical Activity Approach

In the process of mathematics teaching, Chinese mathematics teachers have always insisted an the mathematical activity teaching approach. This idea originated from Dewey's theory of "learning by doing" and Polya's theory about "how to solve problem". They have a huge influence on mathematics education in China.

There are numerous foreign educational theories. They spread to China only about a hundred years ago. Among these theories, Dewey's pragmatism is very close to Chinese traditional emphasis on practicality and Polya's "how to solve problem" is accordant with Chinese consistent emphasis on problem solving. These two ideas are easily accepted by Chinese mathematics teachers and merged well with mathematics teaching in China.

From the modern education of perspective, these two ideas have developed into the "mathematical activity approach".

Several Characteristics of Mathematics Education in China

Explicit Objectives and Refined Knowledge

In China, the syllabus, the examinations, and the curriculum set different objectives for knowledge mastery; however, when teaching, these objectives need to be further refined so that they are more operational and can

be easily understood by teachers and students.

The teaching objectives are divided explicitly into four operable levels: knowing, understanding, mastering, and agile application. The objectives are implemented through the corresponding "actions" and exercises.

Each chapter, each unit, and even each lesson has its respective specific objectives (of knowledge, skill, and method). Teachers strictly follow the hierarchy of the objectives set for each level. For each lesson, teachers design their lesson plans according to the teaching objectives so as to implement the objectives in earnest.

Teachers prepare thoroughly for each lesson by carefully analyzing the key points, difficulties, and attention points. The school mathematics Teaching Research Group or mathematics teachers of the same grade would prepare the lessons together and unify ideas for teaching. They collectively handle the objectives for understanding the mathematical objectives and the depth of explanation in teaching, as well as the selection of the corresponding examples and exercises. The Teaching Research Group at the province level, the municipality level, and the district level will provide guide for teaching. The implementation of the guide is an expected governmental behavior. The corresponding teaching reference books provide authoritative analysis on the contents in the textbooks.

Review Prior Knowledge and Develop New Knowledge

Developing "new knowledge" from "prior knowledge" is a major method of teaching mathematics in Chinese classrooms. In our classroom teaching of mathematics, most new knowledge is developed from existing knowledge. This is consistent with the development of human knowledge, cognitive theories, as well as ideas from constructivism.

Two possible tendencies could happen when adopting this method: on the one hand, students are perplexed with existing knowledge and new scenes may be constructed. In this process, students are inspired and encouraged to know, discover, and then form new knowledge. Students can experience the process of knowledge origination and development.

However on the other hand, the method may be easily distorted. The process of knowledge development is ignored. Teachers may directly "pump" new knowledge into students and may only require procedural knowledge.

Thus, students may passively accept knowledge. We should avoid the second possibility.

Today, diverse ways have been developed to introduce "new knowledge", for example, introducing them from the perspective of "real life problems", "authentic situations", or "mathematical problems" and introducing from "comments on exercises", "designed scenario", or "suspense".

"Two basics" Teaching and Insights Come Out of Familiarity

"Two basics" teaching is an invention of Chinese mathematics education. It receives the highest level of attention in Chinese mathematics teaching, which is mainly reflected in that there are exercises for each lesson, each unit, and each chapter, as well as in-class and after-class exercises.

"Insight comes out of familiarity" is an undivided attitude with "two basics" teaching. "Insight comes out of familiarity" is a well-known Chinese proverb. It is normally translated as "*practice makes perfect*" which has literally distorted the original meaning of the proverb. Chinese mathematician Hua Luogeng said: "working hard is number one. Only when you know it well, you are able to innovate. Working hard helps make up for your handicap; you will get only what you put in." And another Mathematician Chern Shiing-shen also mentioned that "to do mathematics, you must practice and practice until you are good at it; then you will be able to understand and to innovate."

"Insight comes out of familiarity" means repeatedly applying the basic knowledge in problem solving and engaging in extensive exercise, so as to remember and understand the knowledge, and repeatedly practicing the basic skill so as to achieve agile application. For example, use the "9×9 multiplication table" to do oral calculation and mental arithmetic. This kind of memorization contributes to understanding and also helps to gain speed by proficiency. However, this is not simply doing practice. It requires understanding by analogy and comprehending through connections.

Besides, we should also notice that this method may easily lead to the opposite side. It is difficult to control the "extent" of practice, thus, it may easily be distorted as rote learning.

Understand with Depth and Practice with Variation

Chinese mathematics teaching pays great attention to the depth of the understanding of new knowledge. First, it requires thoughtful analysis of new concepts and key phrases in new statements, summarization of the key elements and attention points of new knowledge, as well as clarification of the connections between new and prior knowledge.

Second, it uses variations to deepen the understanding of the essence of new knowledge. Here, variation refers to representing mathematical objects from different backgrounds and different perspectives and changing the nonessential attributes while maintaining essential attributes. There are two types of variations: conceptual variation which means understanding concepts from multiple perspectives, and problem variation which means managing to solve one category of problems.

Practice with variation is an important feature of mathematics education in China. Variations are helpful for students to gain a comprehensive understanding of new knowledge. Thus, they are not only useful for building a solid foundation but also conductive to ability development.

Mathematical Communication and Student-teacher Interaction

China has a large population. Thus, a significant feature of Chinese schools is their large classes with about 60 students. As a result, it is relatively difficult to carry out activities like "small-group discussion and representative reports." How to reduce the possibility of teachers' "cramming" and increase the interactions well with students in class becomes a major concern in mathematics teaching. The mathematical communication in Chinese classrooms has its distinguishing characteristics, for example:

   • teacher asks question-student answers; combination of speak & write, blackboard & textbook, mental arithmetic & written calculations;
   • speak-repeat, repeat again, mutual complement, correct each other;
   • inquire, retort counter-examples, harmony conforming, achieve consensus,

In the process of such teacher-student communication, students' verbal ability continues to be developed and improved from inaccurate to accurate and from loose to rigorous. They need to shift between real-life

language and mathematical language, symbolic language and graphic language. No wonder when some foreign scholars visit China, they are so impressed by the ability of Chinese students' mathematical presentation and communication.

Penetrate Ideas and Master Methods

Infiltration of mathematical thinking is another great invention of mathematics teaching in China. It originates from the guide and influence of Chinese mathematicians. Mr Hua Luogeng first proposed the idea of the "combination of algebraic and geometric approaches." Also, in 1980s, Mr. Lizhi Xu introduced in the 1980s theory about mathematical thinking.

The major mathematical ideas in middle schools are: conversion into an equivalent problem, combination of algebraic and geometric approaches, algebraic equations, solving by exhaustion, geometrical transformation, conversion between finite and infinite, and conversion between certainty and uncertainty.

The major mathematical methods include: change of variables, elimination method (in solving simultaneous equations), reduction of dimensions, formulation of equations, proof by contradiction, proof by transposition, cross-multiplication method, and indeterminate coefficients.

Currently, mathematics teaching is trying to strengthen the infiltration of mathematical thinking and mathematical methods in all areas. In classroom teaching, teachers help students' grasp the essence of mathematical ideas, guide them to apply the mathematical methods in problem solving, reflect on and summarize their learning with mathematical ideas so as to improve students' ability in problem solving.

Develop Thinking and Cultivate Ability

Developing students' mathematical thinking is an important tradition of mathematics teaching in China. Traditionally, the Chinese believe that mathematics is the gymnasium of thinking and mathematics can make learners smart. It is well-accepted that mathematics is one of the best subjects for developing people's thinking.

In mathematics teaching, teachers pay much attention to the

development of students' mathematical thinking, especially its flexibility, agility, fluency, reflexivity and creativity. In the teaching of problem solving, they advocate students' independent thinking, emphasize the exploration of idea, and encourage multiple solutions. Teachers emphasize reflection and encourage achieving understanding, obtaining regularity, and facilitating knowledge transfer from reflection.

The acquirement of "three mathematical abilities" is an important objective of mathematical teaching in China. It was written into the Chinese mathematics syllabus in 1963. The three mathematical abilities refer to the abilities of basic operation, space imagination, and logical thinking. From 1980 to 1990, there was a nationwide large-scale discussion on mathematical thinking and mathematical ability. Experiments on the teaching of mathematical thinking were actively conducted and the teaching of mathematical thinking was improved. The penetration and mastery of mathematical thinking also contributed significantly to the development of thinking and the cultivation of ability.

Pros and Cons of Exam-orientation

The examination is a great feature of Chinese Education. It is part of a typical Chinese traditional culture. There are exams at different stages of semesters, e.g., monthly exams, unit tests, mid-semester exam, and final exams. These are inter-school exams. Besides these, there are different types of tests, e.g., nationwide university entrance examination and regional teaching quality tests.

Though the examination system has many negative effects, it also maintains positive leading role. Examining the "two-basics" is the focal point of all the tests; this attracts more attention to the "two-basics" teaching. Exams are useful in testing mathematical thinking and mathematical abilities; this fosters the teaching of mathematical thinking skills. Exams can reflect students' application of mathematical ideas; this facilitates the penetration of mathematical ideas in teaching. Exams can also test students' ability of mathematical reading and language expression; this helps to enhance the mathematical communication in teaching.

In China, the University Entrance Examination is a fair and transparent selection test; until now, we haven't found a better selection method to replace

it.

Remarks

Although mathematics education in China has many good traditions, we have to admit that it also faces many problems. For example, students' schedules are overloaded with study. Due to too heavy a workload, students are sick of studying. Currently, this phenomenon is quite common and there is the tendency to become worse. Suffering from population pressure, the intense employment competition has further translated into the pressure of university entrance examination. The society and the government consider the results of the university entrance examination as the major criterion for the evaluation of schools. This has forced education in primary schools and middle schools to pay excessive attention to the scores on exams. As a result, the phenomenon of high-score but poor-ability becomes more serious. There is even an increasing trend for the phenomenon of high-score but poor-morals. Such situations are of great concern.

There are some other erroneous tendencies existing in Chinese mathematics education. Specifically, our education tends to place emphasis more on concrete knowledge than methods, on theory more than application, on memorization more than thinking, on dominant knowledge more than recessive knowledge, on deduction more than induction, on proof more than discovery, on review more than teaching of new contents, and on teachers' teaching more than students' creation. These erroneous tendencies are at different levels of seriousness; however, they, in varying degrees, erode Chinese mathematics education.

Chinese Mathematics Education still has a long way to go.

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