Chapter 14
Chinese Mathematics Teaching Methods Reform in the 21st Century

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Abstract Curriculum reform is the key to basic education reform, just as teaching reform is fundamental to curriculum reform. Since the beginning of the twenty-first century, based on the "Two Basics", the emerging mathematics teaching approach and the pedagogy of variation, a great many outstanding achievements in the field of mathematics teaching reform have shown in China.

14.1 Background

Curriculum reform is the key to basic education reform, just as teaching reform is fundamental to curriculum reform. Since the beginning of the twenty-first century, based on the "Two Basics", the mathematics teaching approach and the pedagogy of variation, a great many outstanding achievements in the field of mathematics teaching reform have shown in China. These include the GX Experiment conducted by Chongmu Chen and Naiqing Song from Southwest University, Mathematics Teaching Efficiency carried out by Guangming Wang from Tianjin Normal University, Mathematical Situations and Problem-Posing proposed by Chanhan Lv and Bingyi Wang from Guizhou province, and Implementing Mathematics Methodology and Enhancing Student Quality (also called the MM experiment) conducted by Liquan Xu from Jiangsu and Shangdong Dulang Kou. In addition to these experimental studies, Chinese students' excellent performances in the mathematics Olympics and TIMSS, Shanghai students' first ranking in PISA have all attracted worldwide interest in mathematics teaching in China (Kan, 2015). As mathematics educators from other countries become interested to know more about Chinese mathematics education, it is important to document its development.

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14.2 Inheritance and Innovation: The Mathematics Teaching Reform Experiment

14.2.1 Mathematics Teaching Reform Based on Traditions

Traditionally, the arrangement of textbooks follows the sequence of definition-theorem-proof-examples; in line with this, the teaching model follows the sequence of organization-review-teaching new lessons-conclusion-assignment, which is typical Kairov's "Five-Step Teaching". This teaching model has been adopted by many Chinese primary and middle school teachers and is recommended highly by educators in China. The advantage of "Five-Step Teaching" lies in that it is easy to carry out in real classrooms, can be combined with mathematical deduction and is welcomed by teachers. However, some problems will arise if focus too much on the teachers' teaching and ignore students' learning.

Seeing the potential problems, many schools and teachers are trying to make some changes. Some typical teaching methods introduced since 1990 are the Self-Study Guide Pedagogy proposed by Zhongheng Lu, Qingpu, the Teaching Experiment by Lingyuan Gu from Shanghai, the GX Experiment conducted by Chongmu Chen and Naiqing Song from Southwest University, and "Self-Study-Discussion-Guidance" put forward by Yunan Li.

14.2.1.1 Self-study Guide Pedagogy

The Self-Study Guide Pedagogy was developed by Zhonghe Lu, a professor from the Chinese Academy of Sciences Psychology Department, in 1958. The experiment was carried out in more than 30 provinces around China. The teaching model consists of five parts: enlighten, read, practise, understand and conclude. Teachers help all students with the "enlighten" and "conclude" phases at the beginning and end of the class, each part lasts for 10–15 min. The students spend the remaining 30–35 min in the middle of the class reading, practising and understanding the mathematics content by themselves. The underpinning philosophy of this model is to develop students' self-study abilities, enhance both teachers' and students' enthusiasm for study, build students' learning confidence and develop good self-study habits.

14.2.1.2 Qingpu Teaching Experiment

In 1977, after a three-year survey, one year of selection, three years of scientific experiment and seven years of application, Qingpu Teaching Experiment was introduced as a new teaching pedagogy. Two books were published, *Learning to Teach Based on the Qingpu Experiment* (Mathematics Reform Group from Qingpu Shanghai, 1991) and *Teaching Experiment—the Method and Themes of the Qingpu Teaching Experiment* (Gu, 1994).

There are four principles underpinning this model: motivation, sequence, activities and feedback. To be precise, the motivation principle is the reason for students to study, while the sequence principle is for a structure for the teaching content and process. The activities principle refers to the teaching pedagogy and the feedback principle is concerned with performance. This model has six main steps: arouse students' interest by creating problem situations; try to explore knowledge; form a conclusion; practise with variation; organize thoughts and regulate feedback.

14.2.1.3 Self-study-Discussion-Guidance Pedagogy

There are three tenets to this pedagogy. Self-study is the base, while discussion is the bridge and guidance is essential. Combined, these three contribute to building students' learning ability.

14.2.1.4 GX Experiment

The GX experiment was concerned with enhancing the efficiency of middle school mathematics classes. It was the work of Professor Chongmu Chen and Professor Naiqing Song from Southwest University in 1992. The main purpose of this experiment is to relieve the pressures of study while increasing the learning quality at the same time. The big idea can be underpinned by the following words "moving forward positively, circulation rise; stressing the nature of mathematics rather than the form, coming straight to the point and concentrating on proper issues, studying prior to teaching, and co-performance of the teacher and students" (Chen, Zeng, & Song, 1994). The experiment was carried out in hundreds of schools across 14 provinces and was welcomed by students and teachers (Pang, 2007).

The sequence of the GX model is to focus on problems, then followed by practice in class, give feedback in relation to the practice, and reflect and carry out an assignment. It is based primarily on lecture-type teaching, but also combined with guided-discovery and activity teaching. It is suggested that teachers relate mathematics content to students' real lives. Xiaoda Zhang commented that "If we sum up GX into one sentence, it is that it encourages using the least time to learn more useful mathematics" (Zhang, 1995). The essential part of the model is teaching meaningfully while learning productively.

14.2.1.5 MM Experiment

MM is short for the Mathematical Methodology Education Pattern, which was proposed by Liquan Xu from the Jiangsu Education Research Institute. This experiment started in 1989, requiring teachers to carry out technical and cultural education in their classes and teaching students how to prove, guess and do research. The teacher's role was to help the students to improve their scientific and

social literacy. The model was based on eight themes, returning to nature, aesthetics, discovery method, moral quality, history, deduction, plausible reasoning and general problem-solving (Xu & Yang, 2002).

14.2.2 Mathematics Teaching Reform Based on Learning Cases

The Learning Case approach emerged in China in 1997. Now, it has come to be a leading teaching reform and is well accepted by almost all primary and middle schools in China. There have been a great number of research studies and publications relating to this model. The Jinhua No. 1 Middle School in Zhengjiang was the first school to adopt the learning case model, and Donglu Middle School in Zhengjiang reported remarkable results from it. The essential theme of this model is for students to self-study first, then be taught by their teachers. In 1999, the Hujian Middle School proposed a five-step process: preparation-self-study (students)–discussion (students)–inspiration (teacher)–extension (teacher) (Wan, 2015).

In 1997, the Jinhua No. 1 Middle School followed three stages in the process of developing the model: first the teachers in the school worked together to develop after-class activities; second, they developed activities to be completed before the subsequent classes and third, a uniform teaching plan was developed. In 1998, the Dulang Kou School modified this model by proposing three parts, preview, demonstration and feedback, and six steps, preview and communication, clarification of goals, group cooperation, demonstration, reinforcement and assessment (He & Xu, 2009). This model enables students to enjoy a more open study environment. The concept of "students teaching students" also motivates them. However, there are some disadvantages of this philosophy of "teach less but learn more". Some of the "lecture and study" activities are not particularly meaningful, and the idea of students teaching students can result in that they learn less knowledge and may not use their study time efficiently.

Influenced by the Dulang Kou model, many areas started to develop their own variations in efforts to achieve high results. Due to the range of experiments that ensued, there are now many variations of the learning case model. For example, Jinfeng No. 3 Primary School in Ningxia used a highly efficient model which advocated "studying first, teaching later", and "How to teach depends on students' learning results". This model resulted in the development of seven teaching models and more than 20 teaching themes. The Shiji Middle School in Zibo set up a new teaching model, with five steps. The first step is to guide students in self-study according to the textbook and other related materials. The following four steps are demonstration, practice, assessment and feedback (Hu, 2008).

The DJP teaching model was proposed in the Long Quanyi District in Chengdu, Sichuan province. This consists of three parts: study guiding, explanation and assessment (Wang & Wang, 2013). Study guiding is the fundamental base,

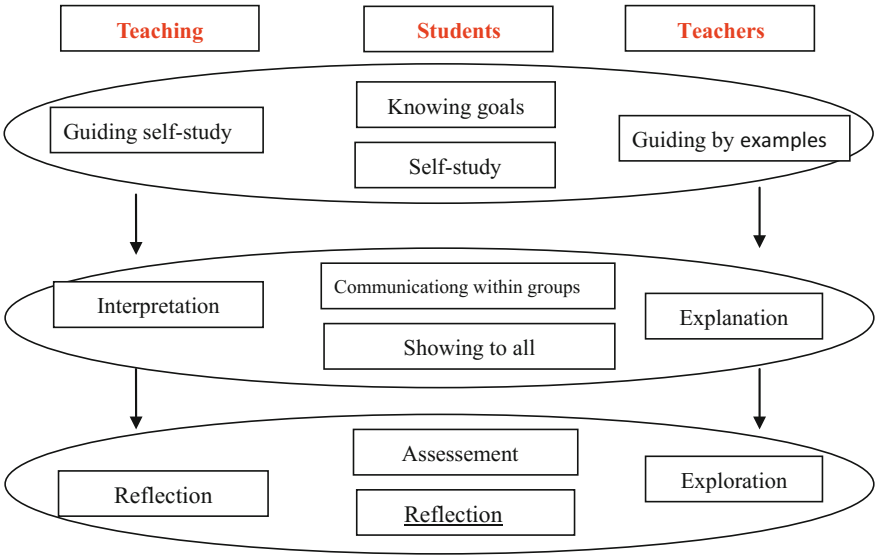

Fig. 14.1 Teaching process of DJP

focusing on "what to learn", while explanation is concerned with "how to learn", which involves both teachers and students, and assessment relates to the achievement of the teaching goals, "how is the learning". It is only real DJP teaching if the three parts come together. The teaching process is summarized in Fig. 14.1. This model was developed over a period of six years, with 3274 teachers in 23 schools.

14.2.3 The Situational Teaching Method

Linking mathematics to real life is one of the most important ideas of the curriculum reforms of the twenty-first century. In 2000, Chuanhan Lv and Bingyi Wang, from Guizhou Normal University, proposed the situational teaching method that aims to develop innovative thinking and practical abilities. The experiment was introduced into schools in 2001 and continued with some outstanding achievements for the following five years (Lv & Wang, 2006).

This model has four steps, set up mathematics situations, introduce mathematics problems, solve the problems and apply the knowledge.

In situational teaching, teachers help their students to develop strategies dealing with real-life problems and posing new questions. The strategies of setting mathematics situations include: (1) Game situation, (2) Practical situation, (3) Real-life situation, (4) Process situation (5) Suspense situation, (6) Competition situation, (7) Analogy and guessing situation, (8) Argument situation, (9) Constructive situation, (10) Dynamic situation (Wang, 2014). Six strategies of posing mathematics

questions include: cause and effect, comparison, generalization, limit, change and reverse strategy (Zhu & Zeng, 2004).

14.2.4 Mathematics Teaching Efficiency Experiment

Even though many new mathematics teaching theories and models have been developed this century, they need to be efficient; if not, they can lead to discouragement and fatigue on the parts of both teachers and students (Liu, 2006).

A well-known contribution to mathematics teaching efficiency was the study conducted by Guangming Wang, from Tianjin Normal University. His book *Mathematics Teaching Efficiency* compared high-achieving and average high school students in terms of cognition structure and understanding the factors the students themselves believed could affect their learning efficiency (Wang, 2006). The research suggested that teaching efficiency depends on two factors. One is the time that students spend in full, active study. The other is the results of learning, such as scores, self-perceptions of efficiency, cognitive structure and mathematics learning competence (Wang, 2005). The book also pointed out the characteristics of high teaching efficiency: focusing on teaching thoughts, understanding problems and building cognition structures (Tu, Wang, & Yang, 2011). Their psychological model for enhancing students' learning efficiency had four dimensions: reasons, senses, cognition and learning competence. Xinmin Wang modified the model by categorizing content into quantitative and qualitative efficiency and classifying knowledge into explicit and tacit efficiency (Wang, 2006).

A national project titled the Teaching Efficiency Study of Fundamental Education, conducted by Guangming Wang, suggested that highly efficient teaching should focus on scientific, intellectual and aesthetic aspects. To be more concise, being scientific means teachers can establish reasonable goals for a lesson and know its level of difficulty. They should then try to help students with their understanding and cognitive structures. Teachers should be interested in building and knowing various learning methods. The intellectual aspect refers to choosing suitable content and teaching methods and also organizing the classroom effectively. Aesthetics refers to the aesthetics of teaching gestures and language, and even classroom organization (Wang, 2011). In short, the most efficient teaching methods are those that trigger highly efficient study (Wang & Wang, 2011).

14.2.5 Class Selection System

As modern technology develops, it is becoming more common for students to have more flexibility in selecting their classes. For example, in 2004, the Shenzhen Middle School in Guangdong Province offered a combination of compulsory and elective courses, in which students had individual class schedules. In September

2009, Qingdao No. 2 Middle School in Shangdong introduced this system, providing their students with 8 study areas, 14 subjects and 87 modules. Similar systems have also emerged in the Affiliated High School of Peking University, the Affiliated High School of Renmin University and the No. 11 Middle School in Beijing. Beijing No. 11 Middle School won a national teaching achievement in 2014 for its related research, and now has some 4000 course schedules for its 4000 students, which means that almost each student has his or her own course schedule.

The aim of class selection system is to stimulate students' enthusiasm to study and make the classroom a favourite place. Like Dulang Kou and Longquan Middle School, many other schools in China are using group work in classes to enable students to communicate and cooperate.

14.2.6 Teaching Reform Based on Technology

As technology has developed so quickly in the recent decades, many teaching methods have changed to keep up. Teachers are required to combine technology suitably with their teaching (Liu, 2015). The most popular methods of doing so are digital narratives, e-schoolbags, electronic whiteboards, flipped classrooms and micro classes.

14.3 Final Thoughts

14.3.1 Focus on Teaching Integrity

In all of the teaching reforms described here, it is important to keep in mind the importance of a complete teaching process. Even though students' learning is the core, teaching cannot be ignored, since no high-level studying happens without high-level teaching. The argument about whether learning or teaching comes first is meaningless because the two should be happening simultaneously (Cheng, 2015). Attention should be paid to the relationship between teaching and learning in teaching reforms. It is easy for mathematics learning or the role of teacher to weaken in these forms. How to achieve a balance between them is still an issue for teaching reform (Cong, 2008).

14.3.2 Student-centred Teaching and Learning

Professor Sato Manabu from Japan expressed the belief that the problems of mathematics teaching in Japan lie in students depending too much on their teachers

teaching and a lack of initiative on the part of the students (Manabu, 2013). Similar problems also exist in China. However, since Yelan (1997) suggested, "Let the class be more energetic", some mathematics teachers have started to move away from lecture methods and towards more student-centred ones. Methods such as the Yangsi experience, Dulang Kou experiment and DJP model focus on students' learning and developing. The purpose of teaching is to motivate students to learn (Guo, 2008). Students' cooperating in their study and teachers' classroom organization to facilitate this are essential themes of the reform (Wang & Wang, 2015). Teaching reform should not be hampered by a fear of students performing poorly in the beginning as long as educators have clear reform maps in their minds (Tian, 2015).

14.3.3 Appropriate Attitudes to Teaching Models

Generally, each teaching method has its own advantages, so learning from different models is necessary; however, it is important to avoid applying them mechanically. The teaching model directly affects the study efficiency and achievement (Cao, 2007). Whether teaching is successful or not depends on the students' knowledge and motivation, and also the teacher's professional background, attitudes and personality. If students are to develop their own study styles it is inappropriate to choose just one teaching model and use it all the time. Even the same teaching model may be used differently by different teachers or schools. Highly efficient teaching should focus on scientific, intellectual and aesthetic aspects (Wang, 2011). Teachers' creativeness should be encouraged; as Zunshan said, "Teaching is an art. A good artist is not only familiar with all fundamental knowledge, but is also creative and shows his style constantly. Similarly, an excellent educator will not constrain himself into one teaching method, but constantly creates new personal ones" (Cao, 2002, p. 2).

14.3.4 Handling the Relationship Between Teachers and Students, Courses and Classroom Culture

There are six kinds of relationship between teachers and students, courses and classroom culture. Two of these are between teachers and courses, one between students and classroom culture, another between teachers and classroom culture, the next between students and students, and the last is between teachers and students (Hao, 2005). To some extent, teaching is a battle between teachers and students to grab discourse power. It is suggested to give more discourse power to students in order to make independent thinking spaces for them. The key core of education and study is to gain the ability to learn by oneself, to develop independent, creative

thinkers (Zhi, 2007). In the ideal classes, students should try to discover problems, pose their own problems and analyse them, solve them, and apply the knowledge independently. Teachers should leave more room for students to find solutions, patterns, conclusions and themes and build their own thinking; the teacher's role is only to offer the necessary help (Shi & Lai, 2008).

14.3.5 Reforms Affected by Examinations

Since 1980, in order to satisfy the entrance examination, a model of "using two years to teach three years' content and leaving one year to review" has been very popular around China. Even now, examinations still mainly test students' knowledge and skills to solve problems, which limit students' development. When introducing a new reform into schools, teachers on the one hand apply it to meet the policy needs, while on the other hand, they still try to help students get higher scores (Shao & Zhou, 2006). As in China, almost any reforms are affected by the examination-oriented system, so it is important that any reform will not affect students' examination performances.

14.3.6 Avoiding Removing Mathematical Features

Some teaching reforms do not place enough emphasis on the nature of mathematics, and this affects teaching efficiency to some extent. In one way, it weakens the teaching of content, even though it does strengthen discussion and exploration (Guo, Peng, & Yang, 2007). On the other hand, it reinforces the theme that the teacher is in charge of the class (Yu, 2005). Mathematics teaching reformation needs to be carried forward, developed and innovated unceasingly. As Dianzhou Zhang said, "Mathematics is the result of thinking, so for mathematics learning, communicating and discussing is quite important. However, it always requires much more time for one to think. I doubt that the primary and middle classroom could offer enough" (Zhang, 2009, p. 158).

14.4 Conclusion

Philosopher Caracon once said, "It is unimaginable for a community totally become separated from its previous culture. Change without considering cultural issues only incurs tragedy" (Yu, 2003, p. 48). Learning from previous experience is of high necessity.

Throughout the twenty-first century, Chinese teaching reforms have required teachers to update their thoughts and change their teaching models from a single

value orientation to multiple ones. It is highly recommended that teaching methods are able to keep students' desire for knowledge alive, make schools places to "learn" rather than "teach" and turn classrooms into places where teachers can really communicate with their students.

References

Cao, Y. M. (2002). 数学教学模式导论 [Mathematics Teaching Methods Guide]. Beijing: China Federation of Literary and Art Circles Publishing House.

Cao, Y. M. (2007). 中国中课堂教学模式及其发展研究 [Chinese Middle School Teaching model and its Development]. Beijing: Beijing Normal University Press.

Chen, C. M., Zeng, Z. J., & Song, N. Q. (1994). 减轻负担、提高质量——GX (提高课堂教学效益)实验简介 [Relieve burden and enhance quality ——GX, brief introduction]. *Journal of Mathematics Education*, 3(2): 1–4, 61.

Cheng, S. R. (2015). 回到教学的基本问题上去 [Going back to the basic problems of teaching]. *Curriculum, Teaching Material and Method, 35*(1), 21–28.

Cong, L. X. (2008). 讲授法的合理与合法 [The rationality and validity of the lecture method]. *Educational Research, 7,* 64–72.

Gu, L. Y. (1994). 教学实验论——青浦实验的方法学与教学原理 [Teaching Experiment-the Method and Themes of Qingpu Teaching Experiment]. Beijing: Education Science Press.

Guo, J. P., Peng, M. H., & Yang, L. Y. (2007). 正反例在概念教学中的研究和应用 [Using positive and negative examples in concept teaching]. *Journal of Educational Studies, 6,* 21–28.

Guo, S. L. (2008). 杯子边上的智慧 [Wise on the side of cup]. *People's Education, 3*(4), 19–21.

Hao, Z. J. (2005). 探究性教学的实质:一种复杂性思维视角 [Essence of inquiry teaching: A complicated thinking perspective]. *Educational Research, 11,* 66–70.

He, S. L., & Xu, W. B. (2009). 东庐中学"讲学稿"教学改革探索与启示 [Donglu middle school teaching reform]. *Journal of the Chinese Society of Education, 10,* 46–48.

Hu, J. H. (2008). 为学生的终生幸福奠基——山东省淄博市桓台县世纪中学办学侧记 [Shandong Shiji middle school teaching reform]. *People's Education, 2,* 54–59.

Kan, W. (2015). 专题:基础教育课程改革的走向 [Primary and middle school education reforms]. *Journal of Educational Studies, 11*(2), 62.

Liu, S. F. (2006). 厚积薄发 引领数学教学新潮——评《数学教学效率论》 [Mathematics teaching——comments on mathematics teaching efficiency]. *Maths Teaching in Middle School, 23,* 57–58.

Liu, B. Z. (2015, May 21). "互联网 + 教育"将让"个性化"教育成为现实 [*Technology make individual education possible*]. China Education Newspaper.

Lv, C. H., & Wang, B. Y. (2006). 中小学数学情境与提出问题教学研究 [Research on Situational Problems in Primary and Middle School]. Guiyang: Guizhou people's Publishing House.

Mathematics Reform Group from Qingpu Shanghai. (1991). 学会教学 [Leaning to Teach]. Beijing: People's Literature Publishing House.

Pang, K. (2007). GX实验的再研究——GX教学模式的建构 [Restudy of GX Experiment—the construction of GX instruction model] (Unpublished doctoral dissertation). Southwest University, Chong Qing, China.

Sato Manabu. (2013). 学校的挑战 [The Challenge for School: Build Learning Community]. Shanghai: East China Normal University Press.

Shao, C. Y., & Zhou, M. (2006). 试论内容标准、表现标准的特点与关系——基于评价与标准一致性的角度 [Discussion of the relationship between content standard and performance standard]. *Contemporary Educational Science, 10,* 37–40.

Shi, J. M., & Lai, P. G. (2008). 让课堂活起来的力量 [Make classes more energised]. *People's Education, 1,* 44–46.

Tian, H. S. (2015). 落实立德树人根本任务，全面深化课程教学改革 [Implementing the fundamental task of morality education; deepening the curriculum teaching reform]. *Curriculum, Teaching Material and Method, 35*(1), 3–8.

Tu, R. B., Yang Q., & Wang, G. M. (2011). 中国数学教学研究30年 [Research on Chinese Education in 30 Years]. Beijing: Science Press.

Wan, W. (2015). 三十年来教学模式研究的现状、问题与发展趋势 [Reviews on teaching methods in 30 years]. *Journal of the Chinese Society of Education, 1,* 60–67.

Wang, F. Y., & Wang, X. M. (2013). 让知识在对话交流中生成——DJP教学中知识生成的过程与理解分析 [Make teaching happen in discussion-case of DJP]. *Journal of Chinese Mathematics Education, 21,* 3–6.

Wang, G. M. (2005). 重视数学教学效率, 提高数学教学质量——"数学教学效率论"课题简介 [Value mathematics teaching efficiency, advance mathematics teaching quality]. *Journal of Mathematics Education, 14*(3), 43–46.

Wang, G. M. (2006). 数学教学效率论 *(*理论篇*)* [Mathematics Teaching Effiency]. Tianjin: Xinlei Publishing House.

Wang, G. M. (2011). 高效数学教学行为的特征 [Features of effective mathematics teaching behavior]. *Journal of Mathematics Education, 20*(1), 35–38.

Wang, G. M., & Wang, Y. (2011). 高效与低效数学课堂导入的案例比较 [Case study between high efficiency class and lower one]. *Journal of Teaching and Management, 1,* 49–51.

Wang, J., & Wang, M. D. (2015). 高效课堂的建构及其策略 [On the construction of efficient classroom and its strategy]. *Educational Research, 3,* 112–118.

Wang, X. H. (2014). "递进式-四环节"小学数学课堂教学模式研究 [Primary school mathematics teaching model study]. *Teacher's Journal, 14,* 5–6.

Wang, X. M. (2006b). 关于数学教学效率及其效率意识的分析 [Analysis on mathematics teaching effect and its effective consciousness]. *Journal of Mathematics Education, 15*(3), 16–18.

Xu, X. Q., & Yang, S. M. (2002). 数学知识的两种形态与数学教学 [Two forms of mathematical knowledge and mathematics teaching]. *Journal of Mathematics Education, 11*(2), 71–73.

Ye, L. (1997). 让课堂焕发出生命活力——论中小学教学改革的深化 [Let the class be more energetic-on deeping the teaching reform of basic education]. *Educational Research, 9,* 3–8.

Yu, W. S. (2005). 新课程教学改革的成绩与反思 [Achievements and problem reflection of the new curriculum teaching reform]. *Curriculum, Teaching Material and Method, 5,* 3–9.

Yu, Y. S. (2003). 中国思想传统的现代诠释 [The New Interpretation of Chinese Traditional Education]. Nanjing: Jiangsu People's Publishing House.

Zhang, D. Z. (2009). 我亲历的数学教育 [My Own Mathematics Education Experience]. Nanjing: Jiangsu Education Publishing House.

Zhang, X. D. (1995). GX是可能的——写在《GX》第一轮实验完成之际 [GX is possible]. *Correspondence of the Teaching of Mathematics, 4*(2), 42.

Zhi, T. J. (2007). 为思维而教 [Teaching for thinking]. *Educational Research, 10,* 44–48.

Zhu, Y. L., & Zeng, X. P. (2004). 中小学数学创设情境与提出问题的策略 [Strategies of math creating situation and posing problem in the elementary schools junior and senior high schools]. *Journal of Mathematics Education, 13*(4), 93–94.