Practice makes perfect on the blackboard: A cultural analysis of mathematics instructional patterns in Taiwan

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Abstract: *Studies show a sharp difference in math achievement between students in the U.S. and students in several East Asian countries, amongst them Taiwan. It is suggested that the patterns of math instruction applied by teachers may have contributed to these differences. This study intends to investigate the patterns of math instruction applied by the Taiwanese teachers and to delve into the cultural roots of these patterns. Data source includes videotaping of instruction by three middle school math teachers and a questionnaire survey of 297 eighth-graders. It was found that the Taiwanese math instruction pattern may be summarized as a cultural activity of "practice makes perfect, on the blackboard." The underlying cultural beliefs are further explored, including the incremental view of human intelligence, self-improvement through diligent effort, and the teacher's role as an authority figure.*

ZDM-Classification: D40, C20, C70

1. Introduction

A series of international comparative studies on student math performance (Fuson, Stigler, & Bartsch, 1988; Stevenson, Lee, & Stigler, 1986; Stevenson, et al. 1990; Stigler, Lee, & Stevenson, 1990; U.S. Department of Education, 1992; Mullis et al., 2000; Mullis et al., 2004) shows that there is a sharp difference in math achievement between students in the U.S. and students in several East Asian countries, amongst them Taiwan. Stevenson and Stigler (1992) found that the "learning gap" between West (American) and East (Chinese and Japanese) lies in students' and parents' different beliefs, expectations, and satisfaction with academic achievement. However, the beliefs alone cannot explain how student learning in the classroom might have contributed to the sharp differences. The processes and patterns of math instruction applied by teachers in different countries need to be investigated so that we may gather a deeper understanding of how teaching practices in different countries might have contributed to the differences in student performances.

Stigler and Hiebert (1999) analyzed TIMSS videotapes of math instruction by teachers from the U.S. and Japan and discovered an interesting "teaching gap" in math instruction. It was found that students in an American math classroom spent most of their time acquiring isolated skills through repeated practice, whereas students in a Japanese classroom devoted as much time to solving challenging problems and discussing mathematical concepts as they did practicing skills. This difference may be embedded in the different "cultural scripts" concerning the nature of math, nature of learning and role of the teacher in the two countries. In the U.S., where math is perceived more as a set of procedures for solving problems, American teachers focus more on procedural skills and ask their students to practice many times in order to master the skills. Since the practicing of the procedural skills is not very exciting, the teacher's role is to keep students' attention by various non-mathematical techniques and provide relatively error-free practice with a high level of success to avoid frustration. In Japan on the other hand, math is perceived more as a set of relationships between concepts, facts and procedures; therefore, Japanese teachers appear to emphasize more on conceptual understanding, pose challenging problems and engage their students in exploring by developing new methods for solving problems. Frustration is taken to be a natural part of this challenging process.

From this perspective, teaching is perceived as a "cultural activity" in which cultural scripts of teaching/learning and the roles of teacher/ student are learned implicitly through observation and informal participation over a long period of time growing up in a culture. As each society has its own shared value system, teachers of different societies learn the implicit cultural scripts about teaching and learning and thus develop distinct instructional patterns.

Students from East Asian countries including Japan, Hong Kong and Taiwan ranked top in TIMSS 1999 and 2003 (Mullis et al., 2000; Mullis et al., 2004). Hiebert et al. (2003) did the TIMSS 1999 video study of mathematical instruction in

seven countries including Japan and Hong Kong and found that there are strong differences in the lesson scripts of mathematical instruction between these two countries. The investigation of different countries in East Asia such as Taiwan may supplement the existing literature. This study, therefore, intends to examine the processes and patterns of math instruction applied by Taiwanese teachers, who may have learned the cultural scripts of teaching and learning in this predominantly Chinese society with a Confucian cultural tradition.

2. Mathematical instructional patterns

In order to investigate the processes and patterns of math instruction in the classroom, detailed and reiterated analysis of the teaching flow is necessary. Videotaping of a complete unit of math lesson by different teachers is the most effective way to obtain such data.

2.1. Research design

Due to Taiwanese teachers' prevailing reluctance to being videotaped in the classroom, the researchers worked very hard to recruit teachers for the study and finally obtained permission from three math teachers in two middle schools in the Taipei area. This sample of three teachers showed a variation in age and gender. While the two male teachers were new to the profession, the female teacher had more than 20 years of experience.

Each teacher was videotaped on a unit of math lesson lasting three to four periods (hours). A total of 15 periods of lesson instruction was videotaped with the three teachers. The videotapes were then reviewed and analyzed using both quantitative and qualitative methods. A Teacher Observation Schedule, adapted from the Stallings Observation System (Stallings, 1988) was used to quantify the number of instructional activities and teacher-student interactions in the classroom. Occurrences of different types of instructional activities (such as demos, practices and quizzes) and teacher-student interactions (such as instruction-related or management-related interactions) were coded at a frequency of once every 2.5 minutes. Categories of most frequently occurring instructional activities and interactions were found and highlighted. Moreover, a reiterated review of each videotape segment was conducted. The flow of different instructional activities in chronological order was differentiated and aligned, and distinct patterns in teaching flow by each teacher were identified. The instructional patterns common to the three teachers gradually emerged through constant comparison and contrast among the three cases.

2.2. Research outcomes

It was found that the instructional pattern common to the three teachers consisted of the following six steps:

(1) Review of previous materials:

At the beginning of a class, the teacher usually starts with a check of the homework assignment or a quiz to review material taught in the previous period. He/she usually calls on students to write up the procedures and solutions on the blackboard and then checks if the students give the right answers.

(2) Presentation of the topic for the day:

The teacher then moves on to present the new topic for the day by saying, "Today we are going to talk about <a certain topic>." At this point, the students usually "automatically" take out the math textbook and turn to the exact page from which the new topic begins. Most students appear to show a "readiness to learn."

(3) Presentation of definitions of terms and rules:

The teacher presents the new terms and rules by contrasting them with the previously established ones, which cannot apply to the new situation. At this stage, the teacher usually asks some closed questions to check if students get the point. The teacher seems to provide little context relevant to the students' previous experiences and raises few questions to arouse interest or curiosity on the topic.

(4) Demonstration with examples:

After explaining a new term and a new rule, the teacher then demonstrates how to apply the rule and use the right skills to get the answers. He/she usually picks two to four problems of different types and with different degrees of difficulty to illustrate the procedures for solving the problems step by step. In the demo process, the teacher usually highlights the "knack" for deriving correct answers for different types of problems.

(5) Practice on the blackboard and at the seat:

To check if students have learned the rules and mastered the skills, the teacher usually calls on some students by drawing lots or selecting a

certain sequence of students to practice textbook problems on the blackboard while other students do the same problems at their seats. Usually several students are called at a time to solve problems of various types and/or degrees of difficulty. If students at the blackboard are stuck, the teacher will usually help by giving some hints. If the students get the wrong answers, the teacher will then correct the mistakes and remind the whole class to beware of making the same errors. In the case of "hopeless" students, the teacher will solve the problem for the students. With the correct procedures and answers listed on the board, the teacher then asks all the students practicing at their seats to check their own answers against the "standard" ones on the blackboard.

(6) Assignment of homework:

At the end of the class, the teacher usually gives homework either from the textbooks or from self-produced worksheets. He/she may also announce a quiz to be held in the next period on the topic just taught.

It was found that the cycle of teacher introducing new terms and rule (step 3), demonstration with example (step 4), and student practice on the board and at seats (step 5) is usually repeated several times, occupying the major block of an instruction period; thus, little time was spent on managerial or non-instructional tasks. Teacher-student interaction focused more on whole-class instruction in which teachers explain rules and ask closed questions and students respond accordingly.

Comparing our findings with those of Stigler and Hiebert (1999), it was found that math teachers in the U.S. and Taiwan all reviewed previous materials, presented the problems, and asked students to practice problems at their seats. It is the process of presenting the problem that reveals great differences between the two countries. Similar to American teachers, the Taiwanese teachers in our sample focus more on demonstrating procedures rather than on math concepts, and ask students to practice procedural skills rather than understand the reasoning behind the procedures. However, American students tend to practice procedures at their seats, while Taiwanese students practice both on the blackboard and at their seats.

3. Practice on the blackboard

What stands out in the Taiwanese instructional pattern derived from the video study of the three math teachers' instruction is the student's repetitive practice on the blackboard. To further understand when, how and why this repetitive practice is implemented in regular math classrooms, the researchers supplement the video study by conducting a questionnaire survey from the perspective of students.

3.1. Research design

A questionnaire was developed to ask students to identify the following occurrences in their regular math classes: (1) occasions when teachers ask students to practice on the board (such as checking homework, practicing textbook worksheets, or giving quiz answers); (2) ways by which teachers select students to the board (such as volunteering, drawing lots, taking turns, or calling on inattentive students); and (3) reasons why teachers ask students to practice on the board (such as to save time, present the right answer, or make sure students have learned). The questionnaire was administered to a sample of 297 eighth-grade students from four schools in the Taipei area. Descriptive statistics and Chi-square tests were used to analyze the data.

3.2. Research outcomes

The questionnaire survey showed the following results:

(1) When to practice on the board

Among the three occasions for practicing on the blackboard listed in the questionnaire, students' "yes" responses to "checking textbook worksheets answers" were significantly higher than "no" responses ($\chi^2[1, N = 297] = 166.5$, $p < 0.001$). Figure 1 shows the percentage of students who agree that the occasion for practicing on the board was highest for "checking worksheet answers" (87.5%), followed by "checking homework answers" (49.0%), and lastly "checking quiz answers" (25.5%). In sum, students perceive that teachers are more likely to ask students to practice on the blackboard when teachers want to check if students get correct answers on the textbook worksheets after listening to explanations and demonstrations.

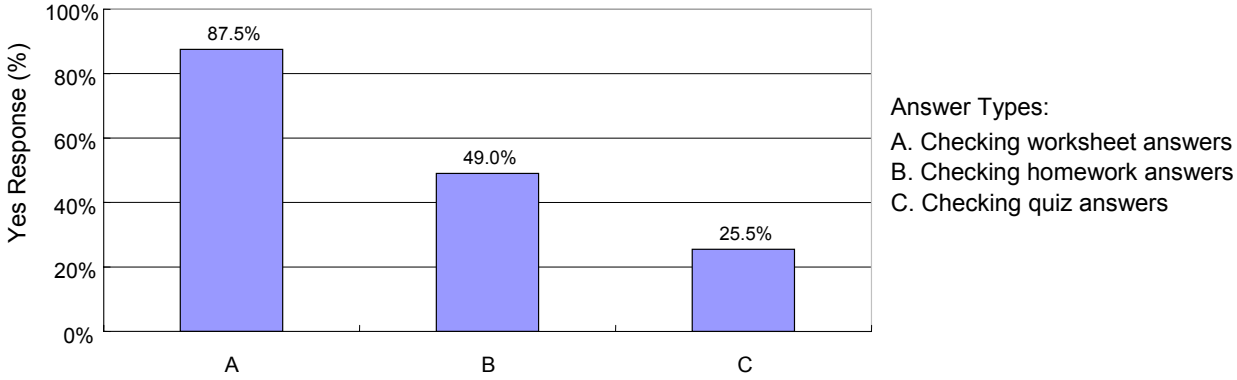

Figure 1. When to Practice on the Board?

(2) How to select students to the board

Among the five ways for selecting students to the board listed in the questionnaire, students' "yes" responses to "calling inattentive students" and "drawing lots" were significantly higher than "no" responses ($\chi^2[1, N = 297] = 104.52$, $p < 0.001$; $\chi^2[1, N = 297] = 32.67$, $p < 0.001$, respectively). Figure 2 shows that the percentage of students who agree that the ways teachers use to select students to the board was highest for "calling inattentive students" (79.9%), followed by "drawing lots" (66.7%), "volunteering" (49.3%), "calling on students who knew the answers" (46.7%), and finally, "taking turns" (26.6%). In sum, students perceive that teachers are more likely to call inattentive students or use lot-drawing when selecting students to practice on the board.

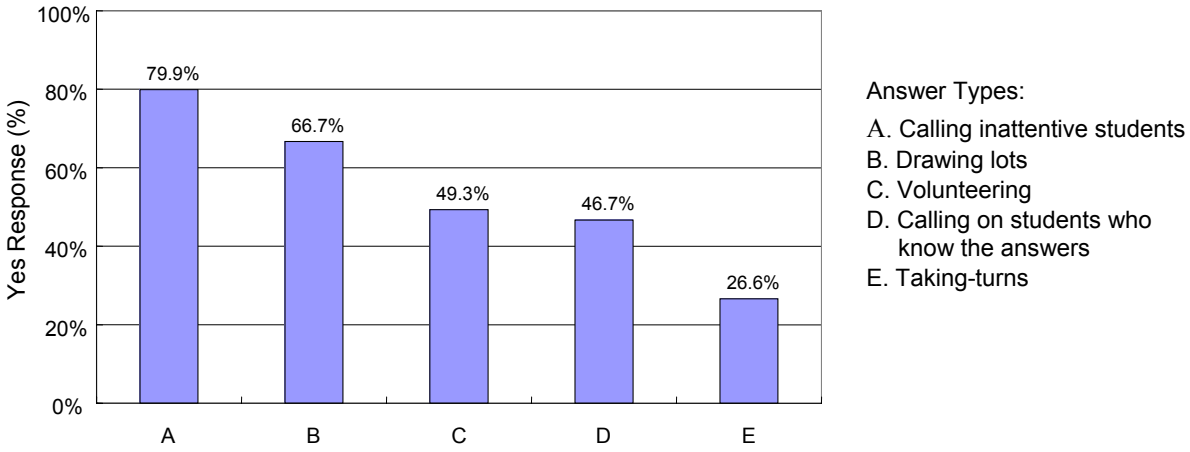

Figure 2. How to Select Students to the Board?

(3) Why practice on the board

Among the five reasons for asking students to practice on the board listed in the questionnaire, students' "yes" responses to "making sure students learn" and "preventing the same mistakes" and "providing different types of problems" were significantly higher than "no" responses ($\chi^2[1, N = 297] = 194.60$, $p < 0.001$; $\chi^2[1, N = 297] = 98.30$, $p < 0.001$; $\chi^2[1, N = 297] = 85.70$, $p < 0.001$, respectively). Figure 3 shows that the percentage of students who agree that the reasons teachers ask students to practice on the board was highest for "making sure students learn" (90.5%), followed by "preventing the same mistakes" (78.9%), "practicing different types of problems" (76.9%), "providing standard answer" (45.1%) and finally, "saving time" (27.6%). In sum, students perceive that teachers ask to students to practice on the board probably because teachers want to make sure that students learn, to prevent students from making the same mistakes, and to provide students with different types of problems to practice.

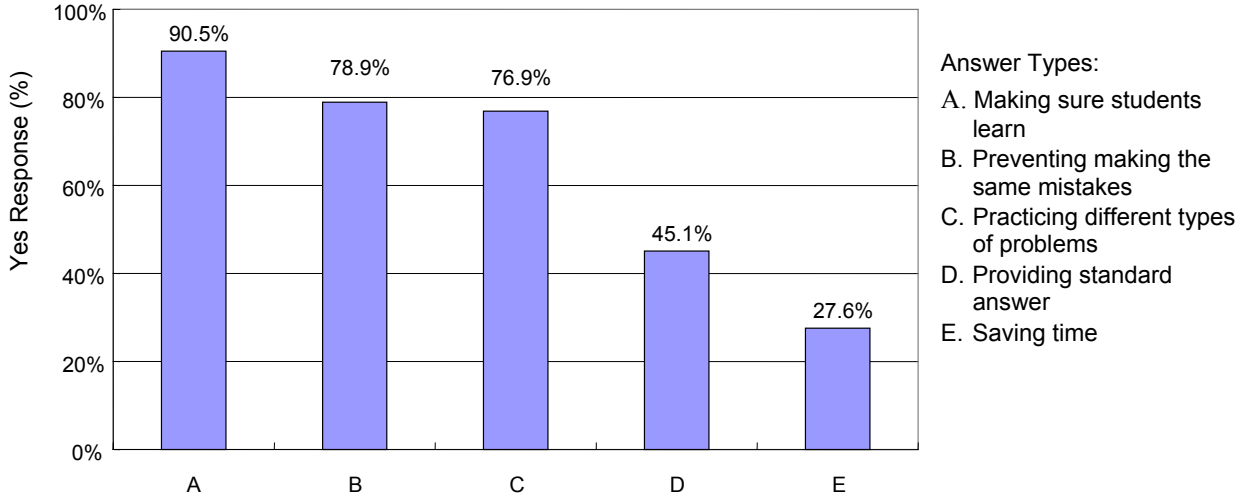

Figure 3. Why to Practice on the Board?

4. Discussion

In summary, from the three cases of math instruction videotaping and student questionnaire survey, it was found that Taiwanese teachers focused more on demonstrating procedures and asking students to practice at seats and on the blackboard. Moreover, teachers usually drew lots or called on inattentive students to practice textbook worksheets on the board for the purpose of making sure that students learn, preventing them from repeating the same mistakes and providing them with different types of problems for practice.

Concurring with Stigler and Hiebert's (1999) argument that teaching is a cultural activity, it is of interest to consider the cultural beliefs underlying the distinctive Taiwanese math instructional pattern.

4.1. Practice makes perfect

The reason why repeated practice at seats and on the board plays such a major role in math instruction in the Taiwanese classroom may lie in the deep-rooted conviction that "practice makes perfect" (*shou neng sheng qiao*). Many Chinese idioms express a concept that places "practice" in the pivotal role in human learning, such as "diligence makes up for inadequacy" (*qin neng bu zhuo*), "a gem unless polished forms no article of virtue" (*yu bu zuo bu cheng qi*), and "perseverance can grind rough iron into a delicate needle" (*tiechu mo cheng xiuhuazhen*). It is believed that only through constant practice can learning be perfected. Therefore, in the context of a math classroom, only through repeated practice on the problem can a student master the skills to solve the problem.

Underlying this emphasis on practice is a deep-rooted view of the "incremental" perception of human intelligence. Dweck et al. (Dweck, 1999; Dweck, Chiu, & Hong, 1995; Dweck & Legget, 1988; Hong, Chiu, & Dweck, 1995; Levy & Dweck, 1998) found that some people hold an "incremental" view while others hold an "entity" view of intelligence. Those who hold the incremental view tend to see intelligence as a malleable quality that can be increased through effort, while those who hold the "entity" view believe human intelligence to be a fixed permanent entity that cannot be changed. This belief may vary with cultures. Cross-cultural studies on people's beliefs in intelligence found that while Westerners tend to hold an entity view, the Chinese tend to hold an incremental view which emphasizes that human intelligence can be perfected (Chen & Uttal, 1988; Tong, Zhao, & Yang, 1985).

Related to this incremental belief in human intelligence is the pattern of attribution to one's effort, rather than innate ability. Weiner (1986, 2001) contend that people attribute their success and failure to innate ability, effort, luck and task difficulty. Many previous studies on student academic achievement found that while Western students were more likely to attribute their academic success or failure to ability, the Chinese tended to attribute their success to effort (Hau & Salili, 1989; Hess & Azuma, 1991; Holloway, 1988; Salili, Hwang, & Choi, 1989; Yang, 1986). They believe that through constant effort-making,

their ability can be incrementally increased and the task of learning can be perfected.

Underlying this emphasis on malleability of ability through effort is the optimistic Confucian view of humanity that everyone is educable, and perfection in human nature can be attainable by all in spite of variance in people's innate ability (On, 1999). As expressed in the Analects (XVI.9), "The smart can learn a task easily and quickly while the dull learn arduously through much practice. But in the end, they all learned". Therefore, one's diligence compensates for inadequacies in innate ability and constant practice can perfect a task of learning. This deep-rooted belief in the malleability of students' learning capacity through effort is revealed in the Taiwanese math instructional pattern, in which the teacher tends to ask students to practice repeatedly at the seat and on the board.

4.2. Practice makes perfect on the blackboard

The distinct Taiwanese pattern focusing on practice "on the blackboard" may be related to, first, a tendency of self-improvement and second, the role of the teacher as an authority figure in the Chinese cultural context.

Kitayama et al. (1997) and Hein et al. (1999) propose that while European Americans show a tendency for self-enhancement, a general sensitivity to positive self-relevant information, and an orientation to enhancing one's own uniqueness and self-esteem, East Asians tend to display an inclination for self-improvement, a general sensitivity to negative self-relevant information, and an orientation to making up for one's shortcomings and perfecting one's actions to meet standards of excellence shared in a social context. In U.S. where the self-enhancing orientation is preferred, teachers are expected to provide practice relatively error-free with high levels of success to avoid frustration, and tend to conceive of errors as a possible precursor to ultimate failure. This may explain why U.S. teachers seldom call on students to practice on the blackboard, because they fear if a student failed to answer correctly and his errors were witnessed by the whole class, this public display of failure might damage the student's self-esteem and counter his self-enhancing tendency (Stevenson & Stigler, 1992).

In a culture where self-improving orientation is emphasized, the Taiwanese teachers and students tend to see errors as an opportunity improve oneself. This is why Taiwanese teachers frequently send a student to the board to display his answers, even erroneous, in front of the whole class. They do not seem too concerned about damaging the student's self-esteem due to public failure and making errors. Instead of seeing the open embarrassment as punishment, they tend to regard mistakes as an indication of what needs to be learned for oneself and for others. For oneself, through persistence and effort, a student can eliminate errors and eventually produce the correct answer. For others, a math error made by a particular student can be instructive because the teacher may use it as an example for correction and as a reminder to avoid that mistake. This is reflected in our student survey that "preventing the same mistake" is one of the main reasons for teachers to send students to the blackboard. In fact, the Chinese character for "error" (*tsuo*) contains the ideogram for "gold," reflecting the idea that even a mistake can harbor golden opportunities for learning.

Another possible explanation for why Taiwanese teachers send students to the blackboard is related to the teacher's role as an authority figure in the traditional Chinese culture. The respect for teachers was so high that the ancient Chinese placed teachers on the same level as "heaven, earth, emperor and parents" (*tien, di, jun, qin, shi*) in the temple of worship (Gao, 1999). Teachers have always been highly respected because they are perceived as "learned scholars" (*jinshi*) who transmit knowledge and skills essential for living and also as "moral figures" (*renshi*) who set good examples for students to follow (Fwu & Wang, 2002; Wang, 2004). Not everyone can be a teacher; only those with great knowledge and virtues can assume this honorable role, implying that teachers are the source of knowledge to their students.

This deep-seated view penetrates into the classroom where students are obliged to listen to the teacher and absorb the knowledge the teacher delivers to them. In this teacher-centered instruction, students usually take a low profile, rarely asking questions or volunteering answers. In fact, students may feel timid about expressing themselves in front of the authority figure (Duncan & Paulhus, 1998; Pratt & Wong, 1999; Tweed & Lehman, 2002). Under this circumstance, the teacher will need to employ tactics to see whether students actually learned

what was taught. Sending them to the blackboard to display math procedures and answers is one effective way to check if students can get the right answers. That's why our survey found that "checking if students learn" is one of the reasons for teachers asking students to practice on the blackboard.

Moreover, since the teacher is regarded as an authority figure, students are expected to show deference by being constantly alert to what the teacher delivers in class. As the teacher is the source of knowledge, learning is viewed as a serious process in which students are expected to fully concentrate. To keep students on alert, the teacher tends to use tactics that may help students concentrate on tasks. That's why our survey showed that "drawing lots" and "calling upon inattentive students" are frequently used methods of selecting students to the board.

As mentioned earlier, teaching is a cultural activity in which cultural scripts of teaching/ learning and the roles of teacher/student are learned implicitly through observation and informal participation over a long period of time growing up in a culture. This study provides a case in point that the Taiwanese teachers, growing up in the Chinese cultural context, have learned and demonstrated a distinct math instructional pattern. This pattern highlights the Chinese deep-rooted belief that "practice makes perfect," and that learning is refined through constant effort in a self-improvement process under the supervision of the teacher as an authority figure.

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