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Connected and culturally embedded beliefs: Chinese and US teachers talk about how their students best learn mathematics

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Abstract

This study compares US and Chinese elementary mathematics teachers' beliefs about how students learn mathematics. Interviews with teachers in each country revealed that Chinese and US teachers have distinct ways of thinking about how mathematics should be taught and how students learn. Many Chinese teachers talked about developing students' interest in mathematics and relating the content of mathematics lessons to real-life situations. The US teachers talked about students' learning styles and using hands-on approaches to learning mathematics. Furthermore, these beliefs may be widespread and persistent within each country because the set of ideas among teachers appear to be internally consistent. Implications for teacher change and the study of teachers' beliefs are discussed.

Keywords: Teacher beliefs; Mathematics education; China; United States; Cross-cultural; Culture

1. Introduction

Teachers' beliefs about instruction and learning may be shaped largely by culturally shared experiences and values. This is critically important in understanding teaching around the world because research (e.g., Richardson, Anders, Tidwell, & Lloyd, 1991; Staub & Stern, 2002) has demonstrated a relationship between teacher beliefs, instructional practices, and student learning. If this relationship is as strong as past research suggests, then understanding the nature of teachers' beliefs may be essential to education reform efforts. Culturally shared beliefs about teaching and learning may be so ubiquitous and familiar that they become difficult to recognize. For this reason, a comparison of teachers' beliefs across cultures can be an especially revealing approach to studying beliefs (e.g., Stigler & Perry, 1990).

Comparisons of US and Chinese elementary-level mathematics education have revealed differences in student achievement (Stevenson et al., 1990) and teacher knowledge (e.g., Ma, 1999), but we know relatively little about teachers' beliefs about student learning. If Chinese and US teachers hold different sets of culturally shared beliefs, these beliefs might further explain differences in elementary mathematics

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teaching and learning in these two nations. Thus, we have chosen to examine Chinese and US elementary teachers' beliefs, with the dual intentions of exploring the cultural nature of teacher beliefs and identifying specific differences and similarities among beliefs in a sample of these two nations' elementary mathematics teachers.

1.1. The role of teacher beliefs in teaching mathematics

The term "teacher beliefs" (also known as "implicit theories," "orientations," and "teacher perspectives") has been used to mean many different things (Furinghetti & Pehkonen, 2002; Pajares, 1992), but for our purposes can be thought of as theories or ideas about what effective instruction looks like and how students learn. Additionally, teachers may hold related epistemological beliefs, or beliefs about what it means to know the subject matter (Thompson, 1992). Teachers' beliefs often guide their decisions in the classroom and can influence many facets of classrooms, including the degree of student autonomy and forms of assessment in the classroom (Stipek, Givvin, Salmon, & MacGyvers, 2001). Teachers' beliefs can also directly correlate with student achievement in mathematics (Staub & Stern, 2002). The relationship between teaching beliefs and practice is further evident in longitudinal studies, which suggest that beliefs and practice change together, often with a change in beliefs preceding changes in teaching practice (Lubinski & Jaberg, 1997). However, the interaction between teachers' beliefs and practice is complex, and a simple causal relationship should not be assumed (Cobb, Wood, & Yackel, 1990; Santagata, 2005). And, at times, teachers' reported beliefs may appear to be inconsistent with classroom practices (Fang, 1996).

1.1.1. Teaching as a cultural activity

Teachers develop culturally shared ideas about what good teaching and learning look like even before they begin their teaching careers. For example, teacher educators find that students who are interested in a teaching career already hold strong conceptions of what good teaching should be like (Wilson, 1990). Where do these come from? Lortie (1975) suggested that teachers may unintentionally acquire culturally shared beliefs about teaching and learning in childhood, when potential teachers are students and participate in an "apprenticeship of observation." Furthermore, these notions about teaching and learning are consistent with broader values within a culture, or shared 'primordial values' such as individualist, community, or collectivist orientations (Alexander, 2001). Stigler and Hiebert (1999) suggested that "cultural activities, such as teaching, are not invented full-blown but rather evolve over long periods of time in ways that are consistent with the stable web of beliefs and assumptions that are part of the culture" (p. 87).

A cross-cultural investigation of teachers' beliefs can be particularly valuable because the comparison of two distinct culturally embedded belief systems can make implicit beliefs and assumptions more transparent. Teachers' ways of thinking about learning and teaching may be difficult to access without cross-cultural comparisons because, within a culture, we have widely held, often unexamined, assumptions. The advantage of a comparative process is that it can make familiar and widespread beliefs within one culture suddenly seem distinctive and unusual (e.g., Jacobs & Morita, 2002). Stigler and Perry (1988) described the benefits of cross-cultural research in mathematics education this way:

> Cross-cultural comparison also leads researchers and educators to a more explicit understanding of their own implicit theories about how children learn mathematics. Without comparison, teachers tend not to question their own traditional teaching practices and are not aware of the better choices in constructing the teaching processes (p. 199).

A comparison of Chinese and US teachers' thinking may lead to a more complete understanding of their beliefs than if either group of teachers was studied in isolation from the other.

1.1.2. The nature of teacher beliefs

Teachers' beliefs may be difficult to change because teaching is a cultural activity, but they may also be exceptionally stable because of a high degree of connectedness among beliefs. In other words, beliefs may tend to be consistent with other beliefs so that one idea about teaching cannot be changed without affecting another. If this is true, teacher change may be exceptionally difficult to achieve without addressing the central assumptions that shape a teacher's collections of beliefs.

Psychologists have long been concerned with the organization of beliefs and the implications for highly structured beliefs systems (Rokeach, 1968). Pajares (1992) synthesized existing research and theory regarding teachers' beliefs and concluded that individual beliefs are organized according to "connections or relationship to other beliefs" (p. 325). Most teachers have many ideas about learning and teaching, and these notions are likely tied to their core beliefs, especially within the domain of education (e.g., Clift & Brady, 2005). If a new idea about teaching or learning is not consistent with central and important beliefs, a teacher may either reject the new idea or transform it to be consistent with deeply held beliefs (Cohen & Hill, 2001). From this, we argue that it may be necessary to understand the connected nature of teacher beliefs before reform in mathematics can successfully initiate changes in teacher practice.

The connectedness of teacher beliefs has been noted, but not explicitly investigated, by many researchers. In this study, we explore both teachers' beliefs and analyze the relations among the beliefs when we ask US and Chinese teachers about their students and their ideas about teaching.

1.2. Why compare Chinese and US teachers?

Although Chinese and US mathematics educational systems have been contrasted, our study fills a gap in these comparisons by examining teachers' beliefs in these two countries. For example, previous comparisons of Chinese and US elementary mathematics education suggest considerable differences in teachers' content knowledge (Ma, 1999) and student attitudes and achievement in mathematics (Stevenson et al., 1990), but we know of no investigations of teacher beliefs about how their students best learn mathematics.

Although we have relatively limited information about student achievement in the People's Republic of China (PRC), Stevenson et al. (1990) found that Chinese first- and fifth-grade students were more competent mathematically than their US peers. The Chinese students were more successful in a range of skills, including computation, word problems, and number concepts. Additionally, comparisons of Chinese and US student, teacher, and parent attitudes toward mathematics revealed significant differences in what it meant to be a successful student in mathematics.

Other investigators (e.g., Ma, 1999), acknowledging Shulman's (1986) notion of pedagogical content knowledge, compared Chinese and US teachers' knowledge of mathematics for teaching. Ma discovered important differences in mathematical knowledge when she studied elementary-school mathematics teachers in Shanghai and Massachusetts. Ma found that Chinese teachers generated more correct answers and more complete explanations in response to math problems than US teachers. Additionally, Ma described a "connectedness" and "longitudinal coherence" in Chinese teachers' thinking about mathematics. An, Kulm, and Wu (2004) built on Ma's work by investigating the relationship between Chinese and US teachers' mathematical knowledge and their knowledge of student thinking. Both studies suggested that Chinese teachers are particularly aware of the importance of students' prior knowledge in comparison to US teachers. This difference, and other similarities and differences between Chinese and US teachers, may emerge in a comparison of teachers' beliefs.

A comparison of teachers' beliefs about student learning can expand our understanding of mathematics teaching and learning in China and the United States, and thereby help explain differences in student achievement and attitudes toward mathematics. The complementary goals of this investigation are to document the beliefs held by elementary mathematics teachers in China and the United States and to explore the cultural and connected nature of these teachers' beliefs.

2. Method

We relied on interview data from elementary mathematics teachers in China and the United States to examine their beliefs about student learning. In particular, we analyzed teacher responses to the question, "How do students best learn mathematics?" In our analysis of the interviews, we characterize teachers' responses according to their location and their students' grade level.

Teacher participants were recruited from public schools in Beijing, China, and central Illinois, United States. The teachers in our sample reflect the populations from which they were drawn, but it is important to note that the teachers volunteered and were not randomly chosen. Thus, although the teachers seem typical, we acknowledge that they are a convenience and not a representative sample.

US teacher participants included 10 first-grade teachers (all female) from six different schools and 11 fourth- or fifth-grade teachers (1 male, 10 female) from five different schools. One teacher worked in a private school and all the other teachers worked in public schools. Five of these teachers worked at schools in rural settings while the other teachers worked in middle-sized Midwestern US cities. Of the 21 participating teachers, 9 worked in schools with over 40% of the student population eligible for free or reduced lunch.

Chinese teacher participants included 10 first-grade teachers (all female) from six different schools and 19 fourth- and fifth-grade teachers (2 male, 17 females) from eight different schools. All of the Chinese teachers specialized in mathematics and taught multiple grade levels of mathematics in public elementary schools in Beijing.

The interviews were conducted by graduate students in each locale. All interviews were videotaped and transcribed. The Chinese interviews were translated into English by native Chinese speakers. Most interviews took place on the same day that the teacher conducted a lesson, which was videotaped by one of the researchers. The interviews were loosely structured around a set of questions that encouraged the teachers to talk about what happened in the observed lesson and their beliefs about teaching and learning mathematics.

Although the interviews included a number of questions regarding teachers' practice, both about the observed lesson and more generally about their practice—such as: "How did you prepare for this lesson?" and "How do you deal with ability differences in the classroom?"—the data presented here result primarily from the one question: "How do students best learn mathematics?" We relied primarily on this question because there were variations in the way many of the other questions were asked. This happened because interviewers interpreted the instructions differently from one another. However, all interviewers concluded the interviews by asking: "How do students best learn mathematics?" Given this question's consistency, and the rich and informative responses from the teachers, we chose to focus on the teachers' response to this question. On occasion, we include responses to other questions when these are illustrative and connected to the teacher's response to the question about how students best learn mathematics.

After the video and transcriptions were prepared, a group of researchers inductively generated categories to describe the teachers' comments in response to the question about how students best learn mathematics. The themes we identified were: hands-on learning, practice and repetition, prior knowledge, learning styles, real-life connections, student discoveries, student interest, and student–teacher relationship. We also identified two different "connections" among themes when teachers talked about two different themes in related ways. We coded instances when teachers mentioned student interest in support of building relationships with students and when teachers mentioned learning styles as a justification for mentioning hands-on learning techniques.

The first author reviewed all the transcripts and identified these themes in each teacher's response to the question "How do students best learn mathematics?" Another author independently examined the same teachers' responses. From these, we calculated Cohen's kappa coefficient. Inter-rater agreement was 0.82 overall, with a range of 0.68–1.00 for individual themes. The level of agreement suggests the coding procedure was reasonably reliable.

This information was then submitted to correspondence analysis. Correspondence analysis is an exploratory analytical technique that represents the distances, or similarities, between participants as well as items in a low dimensional space. The HOMALS program (SPSS, 2004; Van de Geer, 1993) was used to compute scale values for both teachers and the interview themes in this study. We decided to present a two-dimensional solution because it can be meaningfully interpreted by considering the characteristics of the teachers in this study. Additionally, we compiled descriptive statistics to communicate the proportion of teachers in each group mentioning each theme.

3. Results

The teachers revealed many ideas about effective teaching and learning in the interviews. We present a pair of correspondence analysis plots to reflect both the similarities among individual teachers' responses and also the relationship among interview themes. Each point in Fig. 1 represents an individual teacher, and the symbol shape and shading represents each teacher's context (country and grade level). The two-dimensional solution suggests that teachers within each country and grade level are more similar to one another than

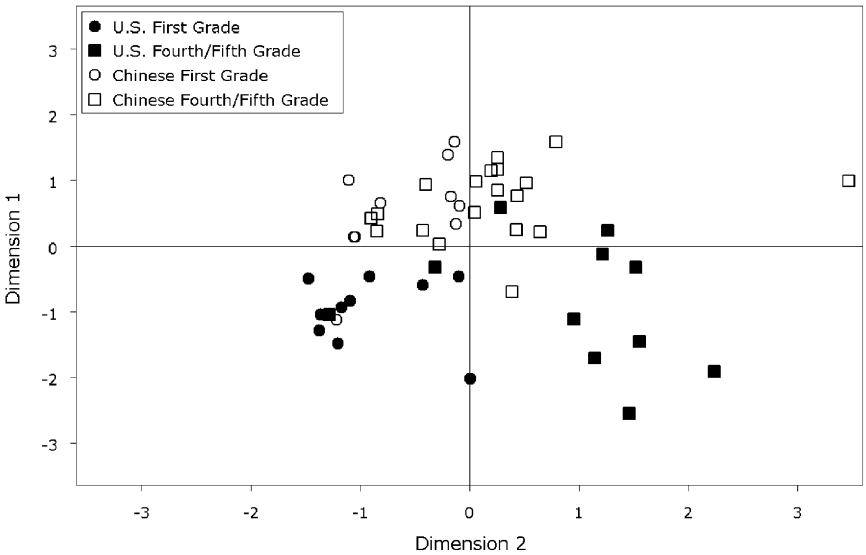

Fig. 1. Representation of the individual teachers.

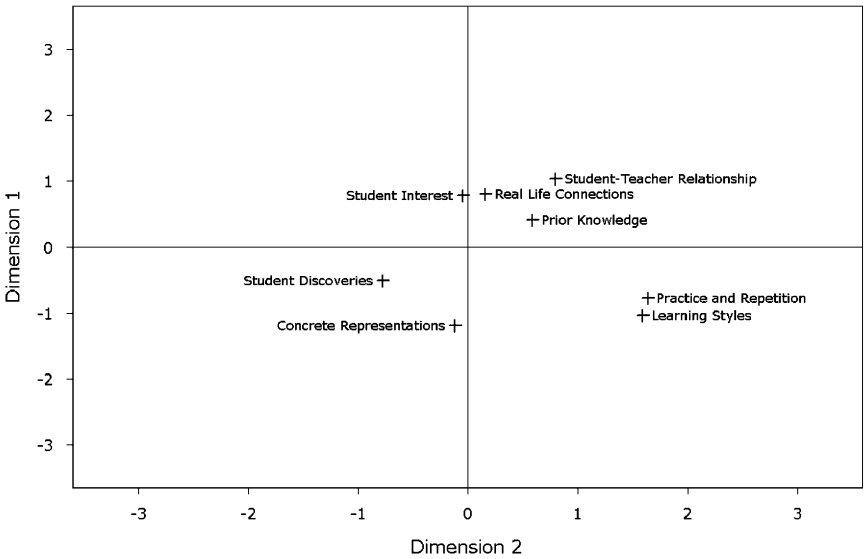

Fig. 2. Representation of the interview themes.

other teachers. The first, vertical, dimension reflects the country of the participating teacher. Chinese teachers are predominantly located in the top half of the plot and US teachers are predominantly located in the bottom half of the plot. The second, horizontal, dimension reflects the grade level of the teacher. First-grade teachers are predominantly located on the left side of the plot while upper elementary teachers are predominantly located on the right side of the plot. Fig. 2 represents the eight interview themes in the same two-dimensional space. These two figures can be used to identify teachers' proximity to other teachers and also to the interview themes. For example, most US first-grade teachers are located in the lowerleft quadrant along with the "student discoveries" and "concrete representations" interview themes. This suggests that these themes were predominantly mentioned by US first-grade teachers.

This technique makes apparent the variance in responses within groups but the results also suggests that teachers who are working in similar grade-level

and cultural contexts tend to share similar ideas regarding how students learn mathematics. For this reason, we will proceed to analyze teachers' responses in ways that are consistent with these groupings. In presenting the results of our analysis, we first describe Chinese first-grade teachers' responses and Chinese fourth- and fifth-grade teachers' responses. We then describe the US first-grade teachers' responses and conclude with a description of the US fourth- and fifth-grade teachers' responses. In each of the following sections, we focus on interview themes in Fig. 2 that are in close proximity to each cluster of teachers in Fig. 1.

3.1. First-grade teachers in China

First-grade teachers in China expressed a variety of values and beliefs about effective mathematics teaching and we will describe three beliefs that were popular with this group of teachers. We found that these teachers valued developing *student interest* in mathematics, *real-life connections* to mathematics to pique student interest, and *student discoveries* of mathematical ideas. This group of teachers mentioned these three themes more frequently than any other group of teachers in this study (see Table 1). We also found that teachers connected these ideas and typically mentioned more than one of these in response to our question.

3.1.1. Student interest

When we asked the teachers how students best learn mathematics, 8 of the 10 Chinese first-grade teachers talked about the importance of student interest in the discipline of mathematics. These teachers seemed to view student interest in mathematics as a prerequisite to learning. For example, one teacher explained student learning this way:

> First, they need to have interest. With the premise of being interested… they can grasp the knowledge in the class. (C1-8)

Many of the teachers who mentioned student interest suggested their primary responsibility as a teacher was to develop their students' interest in mathematics. That is, many teachers stated outright or strongly implied that they held themselves accountable for their students' interest in mathematics. For example, one teacher mentioned this responsibility when she was asked how students best learn mathematics:

> First of all, he should love math. He cannot say, "I don't like math." That won't work for sure. So the teacher must get him to love it. (C1-2)

In summary, most of the Chinese first-grade mathematics teachers in this study mentioned the importance of developing student interest and believed they were responsible for developing their students' interest in mathematics.

3.1.2. Real-life connections

The Chinese teachers' attention to student interest is reflected in their appreciation for real-life applications of mathematics. When we asked the teachers to explain how students best learn mathematics, 5 of the 10 first-grade teachers mentioned real-life applications. Moreover, this was typically talked about as a way to engage students' interest in mathematics. For example, one teacher claimed students will love math if they can realize the usefulness of mathematics:

> Another thing is to connect with actual life. You cannot say math is only math and that it has nothing to do with life. If it can be used in their real life, they will also love it. For example, I'll let them count how many trees there are or how many students are in the classroom. (C1-2)

The teachers' interest in connecting mathematics with students' daily experiences also reflected a general desire to make use of students' experiences and understandings. In a lesson about the numbers 11–20, one teacher explained the importance of learning from other students' experiences:

> In the last 10–20 minutes of the lesson, you should let them say something about their daily use of 11–20 to get them to say more by

Table 1
Proportion of teachers in each group mentioning themes during interviews

	China grade		US grade	
Themes	1	4–5	1	4–5
Concrete representations	.10	.00	.90	.55
Learning styles	.00	.05	.10	.36
Practice and repetition	.00	.16	.00	.55
Prior knowledge	.00	.21	.00	.09
Real-life connections	.50	.21	.00	.09
Student discoveries	.50	.26	.80	.18
Student interest	.80	.74	.10	.18
Student–teacher relationship	.00	.37	.00	.00

> connecting with real life. He will be willing to speak when he feels interested. I feel it's not only teaching to the students, but also a process of learning from each other. (C1-10)

The first-grade mathematics teachers in China seemed to value real-life applications of mathematics in their classrooms. These teachers told us that they valued the strategy of using mathematics examples from real life because they wanted to develop student interest and use students' experiences as learning opportunities.

3.1.3. Student discoveries

The teachers' attention to students' everyday experiences with mathematics was consistent with their student-focused way of thinking about mathematics learning. Many of the Chinese teachers believed it was their role to understand the students' perspective and lead the students to make meaningful mathematical discoveries themselves. Five of the 10 first-grade teachers mentioned the importance of student discoveries of mathematical knowledge when we asked the teachers how their students could best learn mathematics. In addition to sharing their ideas about how children learn best by discovering mathematical principles, the teachers also shared ideas about how they challenged students to come up with their own ideas:

> In today's lesson, first we did it according to the textbook… but they got quite a few new answers. I asked them to find the best strategy from those different answers. (C1-4)

Several of the first-grade teachers in this study shared similar anecdotes and ideas about student learning, but some teachers acknowledged that student-centered instruction with young children can be challenging. One teacher explained that the teacher should "act as a guide and focus on the students," but she acknowledged that "because this is a lower grade, the teacher should guide more than in higher grades." The teachers acknowledged the challenges of this perspective, but half of the Chinese first-grade teachers in our sample suggested that students will learn best when they are asked to construct their own ideas and strategies related to mathematics.

3.2. Fourth- and fifth-grade teachers in China

Chinese fourth- and fifth-grade teachers articulated a range of values and beliefs about effective mathematics teaching and learning, and we will describe three beliefs that were prevalent in the interviews. First, some of these teachers believed students' *prior knowledge* was a key component of learning new mathematical concepts. This student-centered orientation is consistent with the teachers' attention to developing *student interest* in mathematics. Finally, their mindfulness of student interest was demonstrated in the teachers' concern for the *student–teacher relationship*.

3.2.1. Prior knowledge

The fourth- and fifth-grade Chinese teachers in the study were attentive to students' prior knowledge in mathematics because they viewed learning as a process of connecting old knowledge to new knowledge. When we asked the teachers how students best learn mathematics, 4 of the teachers in this group explained that students should have a solid foundation of prior knowledge in mathematics. One teacher said:

> Math is a system of knowledge including many connectors of the old and the new knowledge. Former knowledge will affect the latter and consequently affect learners' interest. So we think a solid foundation is very important. (C5-8)

Additionally, other teachers responded to many different interview questions by mentioning the role of students' understanding of fundamental ideas. For example, one teacher responded to a question about low-achieving students by talking about the relationship between old and new knowledge:

> We need to help them master the prior knowledge well before they go further to the new knowledge. Otherwise they cannot establish the proper connection between prior and new knowledge and they will experience difficulty in further study. (C4-8)

Some Chinese teachers also mentioned the role of students' prior knowledge when describing the way they prepare for a lesson. These teachers' primary concern while planning for a lesson was to assess what their students already understood. For example, one teacher explained that she studies the textbook and tries to "find the connector between the original knowledge and the new knowledge" before teaching a math lesson.

The fourth- and fifth-grade Chinese teachers believed that students learn new mathematical ideas when they build on prior knowledge. The teachers

appeared to be mindful of this idea throughout the interview and mentioned the role of students' prior knowledge in response to a variety of questions. The process of building on old knowledge played a role in how these teachers expressed their thinking about student learning and how they planned their lessons.

3.2.2. Student interest in mathematics

The fourth- and fifth-grade Chinese teachers were also concerned with students' interest in mathematics. Nearly three-fourths of the Chinese fourth- and fifth-grade teachers mentioned student interest when asked, "How do students best learn mathematics?" For example, one teacher told us:

> To learn math, I think first of all he should love it, so that he'll have enough interest in learning. If he hasn't got interest in it, he definitely cannot learn it well. So in my class I'll first try to develop their interest in exploration and learning. (C4-7)

The teachers' concern for student interest was also evident in some responses to other questions in our interview regarding ability differences among students in the classroom. Some teachers believed that low-achieving students were struggling primarily due to their lack of motivation. They often suggested it was the teacher's role to ensure that students were motivated and interested in learning mathematics. Here is one teacher's strategy for responding to students who were struggling to learn mathematics:

> I found several students had some difficulties in comprehending my lesson today. I suggest we should know their feelings and try to motivate their desire to learn. They would learn as much as possible if they have a lot of fun in studying. (C5-1)

These teachers mentioned the importance of student interest with striking regularity when asked how students best learn mathematics. Some teachers also indicated that student interest could be attributed as a cause for low and high achievement in mathematics. In summary, the Chinese fourth- and fifth-grade teachers believed student interest was an important element of effective teaching and learning.

3.2.3. Student–teacher relationship

When we asked teachers how students best learn mathematics, the fourth- and fifth-grade Chinese teachers were the only participants to mention the benefits of a healthy student–teacher relationship. This relationship was viewed as a critical component of learning mathematics; one teacher claimed "students will learn more if they care for their teacher."

The teachers expressed a clear connection between students' affection for a teacher and students' interest in mathematics. All 7 of the teachers who mentioned the importance of a good relationship with students also mentioned the effect that this relationship had on their students' interest in mathematics. These teachers believed that students would take interest in the subject of mathematics if the students liked and respected their teacher. For example:

> First of all… I think I'll let the students love me first. The students need to love their teacher before they love the subject, so I should develop a good relationship with them. (C4-2)

In summary, the Chinese fourth- and fifth-grade teachers placed importance on their relationship with their students. They believed that a good relationship with their students would further students' interest in and learning of mathematics. We now turn to an examination of the US teachers' interview responses.

3.3. First-grade teachers in the United States

Ten first-grade teachers in the United States shared their ideas about effective teaching of mathematics, and two common themes emerged in the interviews. First, half of these teachers believed students would form strong conceptual understandings if the students *discovered* ideas and strategies on their own. Second, this concern for conceptual understanding is consistent with the way almost all of the first-grade teachers in US valued *concrete representations* as tools to develop students' understanding of mathematical concepts.

3.3.1. Student discoveries

When we asked the US first-grade teachers how students best learn mathematics, most of the teachers mentioned the importance of students' construction of mathematical ideas. These teachers believed students should be given the freedom to develop their own understandings and strategies for dealing with mathematical problems. One teacher valued students' creation and sharing of ideas because "if you just put it up there and explain to

them, nobody gets it." Additionally, another teacher explained that asking children how they answered a problem was also beneficial for the teacher:

> I put a problem on the board and I would have five different students raise their hand and they'd all have the same answer. But then when you start asking them, "how did you figure it out?" you would get five different answers. And they'd all get there, and for me that was just very delightful because it was wonderful that we can all use these different approaches [and] it really helped me understand how kids think. (U1-9)

When we asked another teacher how students best learn mathematics, she claimed students learn through exploring and discovering mathematical ideas. However, she also believed this approach required a lot of time and was not always feasible in the classroom.

> I need to be able to let them discover for themselves, and I just don't have time to do that. I think that's how kids learn the best. You know… just let them explore, let them figure things out. I just do not think I have time for it. (U1-5)

In spite of these perceived limitations, many of the first-grade teachers in our US sample generally believed students develop strong conceptual understandings when teachers allow students to develop their own understandings and procedures. These teachers valued divergent thinking among students and believed students learn when they are developing their own ideas and strategies rather than listening to a teacher explain an idea.

3.3.2. Concrete representations

The first-grade US teachers' concern for students' conceptual understanding justified their use of manipulatives in the classroom. When we asked the US first-grade teachers how students best learn mathematics, 9 of the 10 mentioned the importance of manipulatives and hands-on activities to help students learn mathematics. Sometimes, the teachers suggested that hands-on activities supported their goal of allowing students to discover ideas.

> They need lots of exploration with math, they need to use a lot of manipulatives and look at a lot of things thinking mathematically. (U1-1)

Other teachers described hands-on learning as a developmentally appropriate strategy because hands-on learning was necessary for students at this age.

> Obviously, they learn best while they are doing. I mean, that goes even with the brighter students. They still need to see visual a lot of the time. They need to have manipulatives guiding them through at this point. I am sure when they get a little bit further along, that won't be the case, but at this point, they still [need] that idea, that crutch, or whatever. (U1-5)

The first-grade US teachers valued hands-on learning primarily as a way to attend to students' developing conceptual understanding. Although teachers may have meant different things when using the common term "hands-on learning" or "teaching with manipulatives," it was clear that the teachers were concerned that students had concrete representations available to enable them to make sense of the place-value concepts that were the target of instruction. The teachers clearly articulated a belief that young students need concrete objects to explore and understand mathematical ideas and the importance of this belief was demonstrated by the prevalence of their comments about hands-on learning during the interviews.

3.4. Fourth- and fifth-grade teachers in the United States

Eleven fourth- and fifth-grade teachers in the United States shared their perspectives on teaching and learning mathematics and in this section we focus on three common ideas shared by many of these teachers. First, most of the teachers believed that their fourth-grade students needed much *practice and repetition* to master math skills. They also believed that certain students benefited from this more than others, and this belief is indicative of their emphasis on individuals' different *learning styles* in their classrooms. Finally, the teachers also believed that some students' learning styles required *concrete representations* of mathematical ideas.

3.4.1. Practice and repetition

Six of the 11 upper-elementary mathematics teachers talked about the value of practice and repetition during the interview, and some teachers suggested this was an important component of their beliefs about student learning. For example, when

we asked one teacher how students best learn mathematics, she immediately responded, "repetition, repetition, repetition." Many of the upper-elementary teachers recognized repeated practice as a critical tool for learning about mathematics:

> I think that drill is very important… I think that there is just no substitute for going over it and over it and over it until it's very firmly entrenched in their minds. (U4-2)

Also, some of the teachers expressed a belief that certain students benefit from practice and repetition more than other students. Practice and repetition were viewed as ways to attend to individual differences among students:

> With some students, there can be something said for a lot of rote practice at the very beginning of a concept. For instance, if you are introducing regrouping… there are some students who need 40 problems of it just to get the pattern of what they're doing. (U4-3)

In summary, the upper-elementary US teachers seemed to value practice and repetition in the classroom for a few different reasons. First, some teachers simply valued the memorization of math facts or believed that students needed a lot of practice to master mathematical skills. Also, these teachers viewed practice and repetition as one way to attend to students' differences in ability and learning styles.

3.4.2. Learning styles

Many US upper-elementary teachers attended to differences among students in the classroom by adopting different expectations for students of different ability or learning styles. The US upper-elementary teachers were somewhat unique in this respect. They frequently talked about their students by categorizing them as "low students," "middle students," "high-average students," "over-achievers," and "gifted students." Additionally, these teachers also differentiated students by identifying learning styles, such as "visual learners" and "concrete thinkers."

The teachers responded to these perceived differences by assigning different types of work for the students. Some teachers attended to student differences by placing students in small groups with other students of similar ability and learning style. The teachers suggested that students of a particular learning style would benefit from certain types of activities in the classroom. For example, some teachers differentiated "visual learners" from other students:

> And sometimes I use manipulatives for those visual learners, and then sometimes you have those kids who don't need things. (U4-8)

Another teacher suggested certain types of learners need manipulatives:

> I like the hands on… you know you've got the different learning styles so there's always going to be the few kids who might need [manipulatives]. (U4-5)

In summary, some of US upper-elementary teachers expressed concern about attending to the needs of many different types of students in their classrooms. The teachers considered individual differences among students in their justifications for practice and repetition, different expectations of student work, and the use of hands-on activities in the classroom.

3.4.3. Concrete representations

The fourth- and fifth-grade teachers in the US valued hands-on activities in the classroom. Six of these 11 teachers talked about the use of manipulatives when we asked them how students best learn mathematics. These teachers often talked about the use of manipulatives in the process of connecting concrete representations to abstract representations of mathematical ideas.

> I can break it down to its simplest parts and make sure they understand it. And I do that usually by starting off with manipulatives of some form where we...first we play with the things and then we work with them mathematically, and then we're able to take that picture in their head and then go on with the principle. (U5-3)

This group of teachers was unique in the way they described hands-on activities as a way to help particular types of students. These teachers believed low-achieving students or students of certain learning styles would benefit from manipulatives more than other students in the classroom. Four of the 7 US upper-elementary teachers claimed hands-on learning techniques were effective ways to address individual differences in their classroom. None of the first-grade teachers mentioned this connection. For example, one fourth-grade teacher explained

"the kids who are low end get a lot of hands-on" experiences in her classroom. Other teachers claimed some of their students were still in a "concrete" stage of development.

> Well, for lower-level students I really do think manipulatives are important. Give them something concrete to help bridge to the abstract. Most of them have that foundation, but if they don't they have it, they can go grab a clock if they actually need to manipulate the hand to do time instead of being able to figure it out with pencil and paper. (U4-5)

In summary, the upper-elementary teachers valued hands-on learning in the classroom because they believed manipulatives facilitate students'—especially low-achieving students'—understanding of mathematical concepts.

4. Discussion

The Chinese and US teachers shared different ideas when they responded to the interview question concerning how students best learn mathematics, and we also located some differences between the lower- and upper-elementary teachers in their responses. These findings can provide insight into both the role of teacher beliefs in mathematics education in the two particular contexts and the nature of teacher beliefs.

If teachers' beliefs affect their practices in the classroom, a comparison of teachers' beliefs in China compared to the United States can contribute to our understanding of mathematics education in both places (Stigler & Perry, 1990). Although research on US mathematics education is plentiful, there is relatively little research on mathematics education practices in mainland China (but see, for example, Cai, 2001; Ma, 1999). Thus, the interview results can inform our understanding of Chinese mathematics teaching and, at the same time, support and expand past research on US mathematics teaching.

4.1. Confirmation for previously reported findings about US education

International comparisons of mathematics teaching often include teachers and classrooms in the United States (for example, LeTendre & Akiba, 2001; Perry, 2000; Stigler & Hiebert, 1999), and the interviews with US teachers in the current study are generally consistent with past findings. For example, the US upper elementary teachers' emphasis on practice and repetition of mathematical problems is consistent with Stigler and Hiebert's (1999) observation that, in contrast to German and Japanese students, eighth-grade students in the US are "asked to practice and demonstrate procedures on many simple problems" (p. 43). The US upper-elementary teachers' concern for individual differences in learning styles and abilities in this study is consistent with other comparative studies, which suggest that US students and teachers place great importance on stable attributes such as ability when making attributions of mathematical achievement (Stevenson & Stigler, 1992).

We further suspect that the US teachers' responses to our interview questions were influenced by policy context in which these teachers worked. In particular, with the large influence of the No Child Left Behind (NCLB) legislation, the US teachers in our study necessarily were well versed in making certain that their students could practice skills that would translate to acceptable scores on standardized tests. The NCLB influence may have exacerbated some of the fourth- and fifth-grade teachers' tendency to emphasize practice and repetition.

4.2. Confirmation for previously reported findings about Chinese education

Although there is relatively little research on elementary mathematics teaching in mainland China, some of our interview results are consistent with extant and published findings. Comparisons of Chinese and US mathematics teachers that focused on teachers' pedagogical content knowledge concluded that Chinese teachers are more aware of the connectedness of mathematical ideas than US teachers (An et al., 2004; Ma, 1999). This is consistent with findings from our interviews, suggesting that Chinese teachers seek to make connections between new knowledge and prior knowledge when teaching new ideas to students.

The Chinese teachers' concern for the connectedness of ideas should be interpreted in light of differences in teacher training and expectations. Although US teachers usually teach one-grade level and many different types of content, Chinese teachers typically specialize in a content area and often teach the same group of students for multiple years. This context provides more opportunities and incentive for Chinese teachers to think about the relationship among mathematical ideas and the development of children's understanding of these ideas.

4.3. New findings about Chinese education

Some of the ideas that Chinese teachers talked about in the interview have not been reported previously. These findings may provide new insights and raise new questions about mathematics teaching in China. For example, why are Chinese teachers especially concerned with developing student interest in mathematics and how do they attend to this in the classroom? The teachers also claimed to be concerned with good student–teacher relationships, so how are these relationships fostered in classrooms with 40–60 students? Further studies of Chinese elementary mathematics teaching should consider the role of student interest, real-life connections in mathematics lessons, and the role of prior knowledge. If these ideas are shared by other Chinese teachers, then a more complete understanding of how these beliefs interact with lesson planning and classroom activities can improve our understanding of Chinese elementary mathematics education. Further research with larger and more representative samples of Chinese teachers may corroborate these findings or uncover more new findings about the way Chinese teachers think about teaching and how students learn.

Chinese teachers' views on constructivism in mathematics learning may be of particular interest. If constructivism is conceived of as a general perspective on learning rather than a pedagogical technique (e.g., Cobb, 1994), then the results of this study suggest the Chinese upper-elementary teachers' beliefs are more aligned with constructivist views on learning than the US upper-elementary teachers' beliefs. The two groups of teachers' contrasting emphases on building on prior knowledge and practice and repetition are particularly relevant to this distinction. Constructivist teacher beliefs about mathematics are associated with student learning (e.g., Staub & Stern, 2002), so Chinese teachers' perspectives on mathematics learning may help explain achievement differences in the two countries. Further research should examine the relationship between teacher beliefs, instructional practices, and student achievement across cultures.

4.4. Developmental differences embedded in Chinese and US teachers' beliefs

Because many of the Chinese teachers in our sample have mathematics teaching experience in multiple elementary-grade levels, we expected relatively minor differences between the early and upper elementary teachers. This was not the case. In both countries, early and upper elementary school teachers talked about student learning in different ways. For example, many US teachers talked about the benefits of practice and repetition for fourth- or fifth-grade students, but not for the first-grade students. Chinese teachers emphasized about the role of prior knowledge more often for their fourth- and fifth-grade students than for the first-grade students.

4.5. Contextualizing cross-national differences: evidence for considering teaching as a cultural activity

The Chinese and US teachers in this study communicated ideas about teaching and learning that can help describe differences in Chinese and US mathematics education and also inform efforts to reform mathematics education in each country. Teachers often interpret educational reform ideas in ways that are consistent with their existing beliefs about teaching and learning (Cohen & Hill, 2001; Warfeld, Wood, & Lehman, 2005). In both China and the US, an understanding of prevalent ideas about mathematics teaching and learning can help put into context how reform efforts will be understood and implemented in the classroom.

Our findings provide some suggestive evidence about general characteristics of teacher beliefs. First, the similarities of responses among teachers in each context suggest that teaching is a cultural activity. Additionally, teachers' beliefs seem to be organized; in other words, individual beliefs seem relatively consistent with one another.

Teachers within each country mentioned a range of ideas about teaching and learning, but the similarities among teachers in each country were notable. Some themes that the teachers brought up, such as building on students' prior knowledge or attending to different learning styles, were almost exclusively shared by teachers in one country. This finding supports the notion that teaching is a cultural activity and thinking about teaching and learning is informed by culturally shared ideas about teaching and learning (see also Stigler & Hiebert, 1999). Although we did not investigate the origin of teachers' beliefs in our study, we note that the similarities among teachers in each context may be shaped both by common experiences as students and by shared cultural assumptions about how

children learn, much like what Bruner (1996) calls folk pedagogies.

An understanding of culturally shared beliefs about teaching and learning mathematics is an important but incomplete step toward understanding instruction and achievement across cultures. Beliefs and practices interact in complex ways and we should not assume that teachers' beliefs always have a unidirectional effect on teaching. Teachers' decisions are often informed by long-standing cultural practices and organizational structures that may or may not be consistent with their beliefs about teaching and learning (Santagata, 2005).

4.6. The connectedness of teacher beliefs

Although the original goal of this study was simply to document Chinese and US teachers' beliefs, the connectedness of teachers' beliefs became apparent during analysis of the interviews. Teachers expressed a wide range of beliefs and values concerning education, and these beliefs and values often appeared to be consistent with one another. For example, Chinese teachers' appreciation for real-life connections to mathematics appeared to be derivative of a greater concern with developing student interest. Both the early- and upper-elementary US teachers supported hands-on learning activities for reasons that supported their other beliefs about student learning. In the case of the first-grade teachers, hands-on learning was a way to address their concern with young students' conceptual understanding. In contrast, the upper-elementary teachers appreciated hands-on learning as a way to address their concern for students' different learning styles.

The apparent relationships among teachers' beliefs suggest that their individual ideas about teaching and learning cannot change without changing other related ideas. The strength and stability of culturally shared ideas may be partly explained by this phenomenon. If individuals learn about culturally shared values and beliefs through their experiences in and out of school, both when they were students and as teachers, they may be more likely to integrate new ideas and experiences in ways that are consistent with these common, culturally embedded ideas. A handful of important shared beliefs and values may affect the way many educational ideas are interpreted and implemented in the classroom. Educational researchers and policy-makers should consider the structure and complex nature of teachers' beliefs when considering how to facilitate teacher change.

If teachers' beliefs are organized in stable and coherent configurations, this should affect the nature and process of belief change in teachers. Others (e.g., Clift & Brady, 2005; Richardson & Placier, 2001) have already documented that teacher change is difficult and teachers' beliefs may be particularly resolute if they organize in stable and coherent configurations. Belief structures that are highly organized might develop nonlinearly. This possibility is consistent with Nespor's (1987) claim that educator's beliefs function differently from knowledge because beliefs are relatively unchanging and develop through sudden shifts or conversions.

Chinese and US teachers in our sample demonstrated a considerable degree of coherence and connectedness among their beliefs. This is only a suggestive finding, but the evidence of connectedness among beliefs raises important questions about the nature of teacher thinking. If teachers' beliefs and values are consistent with one another, there are important implications for the way we think about educational reform and teacher change. In particular, making substantive changes to teacher practice likely requires making changes to a system of beliefs rather than to a single, isolated issue.

Teachers are a product of their culture and experiences. As we think about improving educational experiences for all students, we need to acknowledge and consider how teacher beliefs and practices are embedded in cultural contexts. Ultimately, by considering the way in which beliefs are situated and connected, we hope to be in a position to affect change in teachers' culturally situated systems of beliefs in ways that lead to more productive learning opportunities for all students.

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References

Alexander, R. J. (2001). Border crossings: Towards a comparative pedagogy. *Comparative Education*, *37*, 507–523.

An, S., Kulm, G., & Wu, Z. (2004). The pedagogical content knowledge of middle school mathematics teachers in China and the US. *Journal of Mathematics Teacher Education*, *7*, 145–172.

Bruner, J. S. (1996). *The culture of education*. Cambridge, MA: Harvard University Press.

Cai, J. (2001). Improving mathematics learning: Lessons from cross-national studies of Chinese and US students. *Phi Delta Kappan*, *82*, 400–404.

Cobb, P. (1994). Constructivism in mathematics and science education. *Educational Researcher*, *23*(7), 4.

Cobb, P., Wood, T., & Yackel, E. (1990). Classrooms as learning environments for teachers and researcher. In R. Davis, C. Maher, & N. Noddings (Eds.), *Constructivist views on the teaching and learning of mathematics. (Journal for Research in Mathematics Education Monograph)* (pp. 125–146). Reston, VA: National Council of Teachers of Mathematics.

Cohen, D. K., & Hill, H. C. (2001). *Learning policy: When state education reform works*. New Haven: Yale University Press.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research*, *38*, 47–65.

Furinghetti, F., & Pehkonen, E. (2002). Rethinking characterizations of beliefs. In G. C. Leder, E. Pehkonen, & G. Torner (Eds.), *Beliefs: A hidden variable in mathematics education?* (pp. 39–57). Dordrecht: Kluwer Academic Publishers.

Jacobs, J. K., & Morita, E. (2002). Japanese and American Teachers' evaluations of videotaped mathematics lessons. *Journal for Research in Mathematics Education*, *33*(3), 154–175.

LeTendre, G., & Akiba, M. (2001). Teacher beliefs about adolescent development: Cultural and organizational impacts on japanese and US middle school teachers' beliefs. *Compare*, *31*, 187–203.

Lortie, D. (1975). *Schoolteacher: A sociological study*. Chicago: University of Chicago Press.

Lubinski, C. A., & Jaberg, P. A. (1997). Teacher change and mathematics K-4: Developing a theoretical perspective. In B. S. Nelson (Ed.), *Mathematics teachers in transition* (pp. 223–254). Mahwah, NJ: Lawrence Erlbaum.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, *19*, 317–328.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, *62*, 307–332.

Perry, M. (2000). Explanations of mathematical concepts in Japanese, Chinese, and US first- and fifth-grade classrooms. *Cognition and Instruction*, *18*, 181–207.

Richardson, V., Anders, P., Tidwell, D., & Lloyd, C. (1991). The relationship between teachers' beliefs and practices in reading comprehension. *American Educational Research Journal*, *28*, 559–586.

Richardson, V., & Placier, P. (2001). Teacher change. In V. Richardson (Ed.), *Handbook of research on teaching* (pp. 905–947). Washington, DC: American Educational Research Association.

Rokeach, M. (1968). *Beliefs, attitudes, and values: A theory of organization and change*. San Francisco: Jossey-Bass.

Santagata, R. (2005). Practices and beliefs in mistake-handling activities: A video study of Italian and US mathematics lessons. *Teaching and Teacher Education*, *21*, 491–508.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14.

SPSS. (2004). *SPSS categories 13.0*. Chicago: SPSS Inc.

Staub, F. C., & Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: Quasi-experimental evidence from elementary mathematics. *Journal of Educational Psychology*, *94*, 344–355.

Stevenson, H. W., Lee, S. Y., Chen, C., Lummis, M., Stigler, J., Fan, L., et al. (1990). Mathematics achievement of children in China and the United States. *Child Development*, *61*, 1053–1066.

Stevenson, H. W., & Stigler, J. W. (1992). *The learning gap: Why our schools are failing and what we can learn from Japanese and Chinese education*. New York: Summit Books.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: Summit.

Stigler, J. W., & Perry, M. (1988). Cross-cultural studies of mathematics teaching and learning: Recent findings and new directions. In D. Grouws, & T. Cooney (Eds.), *Effective mathematics teaching directions* (pp. 194–223). Reston, VA: National Council of Teachers of Mathematics.

Stigler, J. W., & Perry, M. (1990). Mathematics learning in Japanese, Chinese, and American classrooms. In J. W. Stigler, R. A. Shweder, & G. Herdt (Eds.), *Cultural psychology* (pp. 328–353). New York: Cambridge University Press.

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education*, *17*, 213–226.

Thompson, A. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In A. D. Grouws (Ed.), *Handbook of research on mathematics learning and teaching* (pp. 127–146). New York: Macmillan.

Van de Geer, J. P. (1993). *Multivariate analysis of categorical data: Applications*. Newbury Park, CA: Sage Publications.

Warfeld, J., Wood, T., & Lehman, J. D. (2005). Autonomy, beliefs and the learning of elementary mathematics teachers. *Teaching and Teacher Education*, *21*, 439–456.

Wilson, S. M. (1990). The secret garden of teacher education. *Phi Delta Kappan*, *72*, 204–209.