ABSTRACT. Student self-beliefs are significantly related to several types of academic achievement. In addition, results from international assessments have indicated that students in Japan have typically scored above international averages (D. L. Kelly, I. V. S. Mullis, & M. O. Martin, 2000). In this study, the author examined relationships between mathematics beliefs and achievement of elementary school-aged students in the United States and Japan. The students had participated in the Third International Mathematics and Science Study (TIMSS; A. E. Beaton et al., 1996). The author examined several self-beliefs and used variance estimation techniques for complex sampling designs. The author identified a number of significant relationships between self-beliefs and mathematics achievement. Students who attributed success in mathematics to controllable factors (e.g., hard work, studying at home) showed higher test scores whereas students who attributed success in mathematics at school to external factors (e.g., good luck) tended to earn lower mathematics test scores. These results extend the findings of previous research results because the author examined large national samples of students in cross-cultural settings as part of a comprehensive international assessment.

Key words: mathematics achievement, self-beliefs, TIMSS

STUDENT SELF-BELIEFS ARE SIGNIFICANTLY RELATED to several types of achievement outcomes. For example, in a longitudinal study of high school students, Vallerand, Fortier, and Guay (1997) indicated that self-perceptions were significant predictors of subsequent school withdrawal. Likewise, academic self-concept and achievement expectancies were significantly related to the school withdrawal of adolescent students (House, 1999). Researchers have found a sig-
nificant predictive relationship between academic self-concept and subsequent grade performance (House, 1997; Marsh & Yeung, 1997; Vrugt, 1994), and these results have suggested that higher levels of academic self-concept tend to be associated with higher levels of academic achievement. Several facets of academic self-concept (self-ratings of overall academic ability, drive to achieve, mathematical ability) and achievement expectancies (expectations of graduating with honors) were positively related to chemistry achievement (House, 1996) whereas elementary school-aged students’ reading self-concept was significantly correlated with reading achievement (Chapman & Tunmer, 1995). Researchers have found that academic self-concept has a multifaceted structure and students tend to develop self-concepts in specific subject areas, such as reading, science, and mathematics (Marsh & Yeung, 1996; Mui, Yeung, Low, & Jin, 2000). Therefore, it is important to examine specific academic subjects when assessing the relationship between student self-beliefs and achievement outcomes.

To explain student performance in mathematics, Reyes and Stanic (1988) proposed a model to consider the effects of numerous factors, including societal influences, school mathematics curricula, classroom processes, and student attitudes and achievement-related behaviors. Their results indicated that students’ comparisons of themselves with others might influence the expectations for success. Several researchers have found that students’ attitudes are significantly related to their achievement in mathematics. For example, Pajares and Graham (1999) found that mathematics self-efficacy was significantly associated with the achievement of middle school students. Likewise, House (1993) found that students with higher academic self-concepts tended to earn higher grades in mathematics courses, even after controlling for the effects of previous achievement. Furthermore, Marsh and Yeung (1997) found that academic self-concept exerted significant causal effects on the mathematics achievement of adolescent students. In addition, House (1995) found that several facets of academic self-concept and achievement expectancies (self-ratings of mathematical ability, overall academic ability, expectations of graduating with honors) were significantly associated with grades in mathematics courses of adolescent students.

Researchers also have observed the relationship between student beliefs and mathematics achievement in cross-cultural settings. In a longitudinal study of high school students in Hong Kong, Rao, Moely, and Sachs (2000) noted that self-concept of mathematics ability was a significant predictor of subsequent achievement. In addition, researchers have shown that previous achievement exerted significant effects on students’ academic self-concept and motivation. Abu-Hilal (2000) found that students’ perceptions regarding the importance of mathematics exerted a significant effect on achievement and that mathematics achievement then increased self-concept. Results from a longitudinal study of elementary and middle school students indicated that initial mathematics achievement was significantly related to subsequent mathematics self-concept (Skaalvik & Valas, 1999). In conclusion, the relationship between self-concept
and mathematics achievement seems to become stronger as students’ grade level increases (Ma & Kishor, 1997).

Results from international assessments have indicated that students in Japan have typically scored above international averages (Kelly, Mullis, & Martin, 2000). Therefore, researchers have examined the effects of cultural influences and instructional practices in Japan and have identified several differences between Japan and the United States (House, 2001, 2004; Perry, 2000; H. Shimizu, 1998; Stigler, Gallimore, & Hiebert, 2000; Stigler, Lee, Lucker, & Stevenson, 1982; Stigler, Lee, & Stevenson, 1987). For example, H. Shimizu indicated that students in Japan have extensive practice incorporated into their daily routine and Stigler et al. (1982) found that Japanese students are required to complete more daily homework. In an observational study of activities in elementary school mathematics classrooms in the United States and Japan, Stigler et al. (1982) revealed that teachers in Japanese classrooms spent significantly more class time asking academic questions of the entire group whereas teachers in the United States asked significantly more questions of individual students (Stigler et al., 1987). Likewise, Perry found that teachers in Japanese classrooms provided students with more extended explanations in their mathematics lessons. On the basis of classroom observations during the Third International Mathematics and Science Study (TIMSS) Videotape Classroom Study, Stigler et al. (2000) indicated that eighth-grade students in Japan spent more class time on activities designed for inventing and proving and less time on practicing routine procedures than did students in the United States. House (2001, 2004) found that adolescent students in Japan who tended to show high mathematics test scores reported that their teachers more frequently incorporated the use of active learning strategies (e.g., using things from everyday life when solving problems) during mathematics lessons.

To explore other possible explanations for these achievement differences, researchers have conducted an international study to examine cultural factors, such as mathematics curriculum and content, instructional strategies, and students’ learning styles (International Commission on Mathematical Instruction, 2000). Leung (2001) considered East Asian approaches to mathematics and suggested that Asian students have been expected to understand that success is dependent on hard work and studying. In the same way, Asian students were more likely to have parents with high expectations and to indicate that academic success is achieved through hard work (Chen & Stevenson, 1995). Results from international assessments have indicated that students in Japan report more often that they were not doing well in mathematics despite scoring well on achievement tests (Leung, 2002). These findings indicate that there are cultural differences in classroom practices, instructional strategies, and expectations for student achievement in mathematics.

TIMSS (Beaton et al., 1996) represents the most comprehensive international assessment of educational contexts and student achievement (Martin, 1996). As part of the TIMSS assessment, Schmidt and Cogan (1996) constructed a model
to examine the effects of contextual factors on student achievement. Factors incorporated into the model of student achievement have included classroom environments and instructional practices, family resources and expectations, and student self-beliefs. Initial findings from the TIMSS assessment have identified instructional practices and student characteristics that were related to mathematics achievement. It is important to conduct secondary analyses of the TIMSS data to identify specific factors associated with student achievement in cross-cultural contexts (Beatty, Paine, & Ramirez, 1999). Therefore, the TIMSS assessment represents a unique opportunity to examine the relationship between self-beliefs and mathematics achievement for students in cross-cultural settings.

My purpose in this study was to examine relationships between mathematics beliefs and achievement of students in the United States and of those in Japan. I designed this study to extend previous research results that have shown significant relationships between self-beliefs and academic achievement (Marsh, Hau, & Kong, 2002). In addition, I intended to build on recent research results that showed significant positive associations between mathematics beliefs and geometry achievement test scores of adolescent students in Japan (House, in press-a). I had two reasons for examining the achievement of students from the United States and Japan. First, researchers have conducted a number of cross-cultural comparisons between the two countries to compare teaching practices used in mathematics instruction. Schumer (1999) indicated that considerable differences exist in classroom practices, and Hiebert and Stigler (2000) recommended more effective instructional strategies based on Japanese approaches. Experience in mathematics classrooms affects learning outcomes and shapes student attitudes about mathematics (Y. Shimizu, 1996). Therefore, my second reason for examining students from the United States and Japan was to determine if the relationships between self-beliefs and achievement were similar for students from countries in which instructional practices have been extensively investigated. I designed this study to assess those relationships for large national samples of students from cross-cultural settings who were part of a comprehensive international assessment.

Method

Participants

The TIMSS assessment included a two-stage stratified cluster sample design (Foy, Rust, & Schleicher, 1996). In that design, researchers sampled schools during the first stage and then selected individual classrooms from the sampled schools during the second stage. As part of the TIMSS assessment, researchers (Schmidt & Cogan, 1996) used student questionnaires to collect data on student characteristics, instructional activities, out-of-school activities, learning resources, and mathematics achievement. Students included in these analyses
were from the TIMSS Population 1 International Samples (9 years of age; Martin, 1996) from Japan and the United States. There were 8,220 students from Japan and 10,070 students from the United States who completed all of the mathematics belief variables.

Measures

I examined several specific student self-beliefs about mathematics. Four items assessed attitudes about school achievement: (a) natural talent, (b) good luck, (c) hard work studying at home, and (d) memorization of the textbook or notes. With regard to attitudes toward mathematics, I assessed student responses to three items: (a) I enjoy learning math, (b) math is boring, and (c) math is an easy subject.

On each of these items, I transformed original answers so that the questionnaire would follow levels of agreement: strongly disagree (1), disagree (2), agree (3), or strongly agree (4). Last, I examined the dependent measure of students’ scores on the TIMSS International Mathematics assessment.

The achievement test consisted of six content areas: (a) whole numbers; (b) geometry; (c) proportionality and fractions; (d) measurement, estimation, and number sense; (e) data representation, analysis, and probability; and (f) patterns, relations, and functions (Garden & Orpwood, 1996). Reliability for the TIMSS mathematics test was determined by the median KR–20 reliability for the eight test booklets used in each country. Cronbach’s alpha reliability coefficients for the TIMSS assessment used for the Population 1 International Samples were .82 for Japan and .83 for the United States, and the international median reliability coefficient for the lower grade in the sample was .82 (Beaton et al., 1996); reliability coefficients for the upper grade in the Population 1 sample were .82 for Japan, .86 for the United States, and .84 for the international median (Beaton et al.).

Procedure

Statistical procedures using simple random sampling involve assumptions that are inappropriate for data collected from assessments that used complex sampling designs (Gonzalez & Foy, 1997). When researchers use statistical procedures for simple random sampling for data collected from complex sampling designs, underestimation of the errors may occur (Ross, 1979), which can produce spurious findings of statistical significance in hypothesis testing (Wang & Fan, 1997). Hence, it is important to consider the design effect and use statistical procedures that produce unbiased variance estimates to enable the performance of appropriate statistical tests of significance.

Because of the two-stage stratified cluster sample design of the TIMSS assessment (Beaton et al., 1996), I used jackknife variance estimation procedures using replicate weights to compute appropriate standard errors for each variable.
included in this study (National Center for Education Statistics, 1998). Jackknife variance procedures are an effective method for analyzing data from cluster survey designs and provide full-sample estimates for each variable (Brick, Morganstein, & Valliant, 2000). This technique simulates repeated sampling of students from the initial sample according to the specific sample design (Johnson & Rust, 1992). These procedures produce estimates of the population means (and the standard errors of those estimates) and are sometimes referred to as resampling plans (Fan & Wang, 1996). The use of the jackknife replication statistic increases the generalizability of research findings by providing population estimates rather than findings from a single sample (Ang, 1998).

I analyzed the data from this study in two ways. First, I computed correlation coefficients to examine the relationship between each mathematics belief variable and achievement test scores. Second, I used multiple regression procedures to simultaneously assess the relative contribution of each mathematics belief variable toward the explanation of mathematics achievement test scores. For each example, I conducted analyses for the entire sample of students from each country.

**Results**

Table 1 shows descriptive statistics for each mathematics belief variable and for mathematics achievement test scores for both samples. Those values are not descriptive statistics for the samples of students from Japan and the United States. Rather, for each variable, I presented estimates of the population mean and the standard errors of those estimates.

Table 1 also shows correlations between student beliefs and mathematics achievement test scores. I obtained six significant correlations from the sample of students from Japan. Students who reported that they enjoyed learning mathematics and thought that mathematics was an easy subject also tended to earn high mathematics test scores. Furthermore, students who attributed success in mathematics at school to hard work studying at home and to memorizing the textbook or notes also showed high mathematics achievement. However, students who indicated that mathematics was boring tended to show low mathematics test scores. In addition, students who attributed success in mathematics at school to good luck were more likely to show low mathematics test scores. With regard to the sample of students from the United States, six mathematics beliefs showed significant correlations with mathematics test scores. Students who indicated that they enjoyed learning mathematics and who thought that hard work studying at home was needed for success in mathematics at school also tended to show high test scores. However, students who reported that mathematics was boring tended to show low test scores. Likewise, students who indicated that success in mathematics at school required memorizing the textbook or notes also were more likely to show lower mathematics test scores than were those who did not indicate that belief. Last, students who
attributed success in mathematics at school to good luck and to natural talent also were more likely to have earned lower mathematics test scores than those who did not profess this belief.

Table 2 shows results from the multiple regression analyses of the relationships between mathematics beliefs and achievement test scores for the samples of students from Japan and the United States. Six variables significantly entered the multiple regression equation for students from Japan. Three variables showed significant positive associations with mathematics achievement test scores. Students who indicated that it was important to memorize the textbook or notes to

<table>
<thead>
<tr>
<th>Variable</th>
<th>Japan</th>
<th>United States</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>To do well in math at school you need natural talent</td>
<td>3.00 0.011</td>
<td>2.90 0.022</td>
<td>−.240*</td>
</tr>
<tr>
<td>To do well in math at school you need good luck</td>
<td>2.63 0.017</td>
<td>2.63 0.025</td>
<td>−.400**</td>
</tr>
<tr>
<td>To do well in math at school you need hard work studying at home</td>
<td>3.32 0.012</td>
<td>3.62 0.010</td>
<td>.086**</td>
</tr>
<tr>
<td>To do well in math at school you need to memorize the textbook or notes</td>
<td>3.36 0.012</td>
<td>2.96 0.023</td>
<td>−.157**</td>
</tr>
<tr>
<td>Math is boring</td>
<td>1.96 0.011</td>
<td>1.93 0.019</td>
<td>−.175**</td>
</tr>
<tr>
<td>Math is an easy subject</td>
<td>2.47 0.011</td>
<td>2.90 0.015</td>
<td>−.022*</td>
</tr>
<tr>
<td>I enjoy learning math</td>
<td>2.92 0.011</td>
<td>3.29 0.018</td>
<td>.042*</td>
</tr>
<tr>
<td>International Mathematics Achievement Test Score</td>
<td>571.58 1.541</td>
<td>519.28 2.815</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05. **p < .01.
do well in mathematics also tended to earn higher achievement test scores. In addition, students who earned high test scores tended to think that hard work studying at home was needed for success in mathematics at school. Likewise, students who reported that they enjoyed learning mathematics also tended to have high mathematics test scores. Three variables also showed significant negative relationships with mathematics test scores. Students who expressed the belief that mathematics was boring also tended to show low mathematics test scores. Furthermore, students who thought that natural talent was needed for success in mathematics at school also tended to earn lower test scores. Likewise, students who attributed success in mathematics at school to good luck tended to earn low

<table>
<thead>
<tr>
<th>Mathematics belief variable</th>
<th>Parameter estimate</th>
<th>SEE</th>
<th>$F(7, 68)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>To do well in math at school you need to memorize the textbook</td>
<td>17.36</td>
<td>1.95</td>
<td>79.18**</td>
</tr>
<tr>
<td>or notes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To do well in math at school you need hard work studying at</td>
<td>7.55</td>
<td>1.30</td>
<td>33.62**</td>
</tr>
<tr>
<td>home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoy learning math</td>
<td>10.69</td>
<td>1.90</td>
<td>31.69**</td>
</tr>
<tr>
<td>To do well in math at school you need good luck</td>
<td>-18.92</td>
<td>1.15</td>
<td>270.45**</td>
</tr>
<tr>
<td>Math is boring</td>
<td>-10.50</td>
<td>1.79</td>
<td>34.42**</td>
</tr>
<tr>
<td>To do well in math at school you need natural talent</td>
<td>-3.68</td>
<td>1.37</td>
<td>7.20**</td>
</tr>
<tr>
<td>Math is an easy subject</td>
<td>-2.18</td>
<td>1.31</td>
<td>2.77</td>
</tr>
<tr>
<td><strong>$p &lt; .01$.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p < .01.
mathematics achievement test scores. Last, the overall multiple regression equation that assessed the joint significance of the complete set of mathematics belief variables was significant, $F(7, 68) = 124.28, p < .001$, and explained 13.34% of the variance in mathematics achievement test scores for students in Japan.

Table 2 also shows findings from the multiple regression analysis of the relationships between mathematics belief variables and achievement test scores for students in the United States. Five variables significantly entered the multiple regression equation. Students who indicated that hard work studying at home was needed for success in mathematics at school also tended to earn high test scores. However, students who expressed the belief that mathematics was boring also tended to earn low test scores. Students who thought that success in mathematics at school depended on natural talent and on memorizing the textbook or notes also showed low mathematics achievement. Furthermore, students who attributed success in mathematics at school to good luck also tended to show low mathematics achievement test scores. In addition, the overall multiple regression equation that assessed the joint significance of the complete set of mathematics belief variables was significant, $F(7, 53) = 95.47, p < .001$, and explained 19.33% of the variance in mathematics achievement test scores.

Discussion

I found several significant findings from this study. One result was that several mathematics belief variables were significantly related to mathematics achievement test scores for students in both Japan and the United States. For example, students who attributed success in mathematics at school to hard work studying at home were more likely to have earned higher mathematics test scores than were those students who did not indicate that belief. Likewise, students in both countries who showed low mathematics test scores tended to indicate that mathematics was boring and to attribute success in mathematics at school to natural talent. In addition, students from both countries who earned low mathematics test scores also tended to more frequently attribute success in mathematics at school to good luck. I also noted differences in the relationship between self-beliefs and mathematics achievement test scores for students from Japan and the United States. Students in Japan who earned high test scores tended to attribute success in mathematics at school to memorizing the textbook or notes. However, students in the United States who indicated that it was important to memorize the textbook or notes tended to show low mathematics achievement. One possible explanation for this finding may be that memorization in mathematics and science education is used differently in Japan than in the United States. For example, recent approaches in the United States have reduced the emphasis on memorization in mathematics and science education. Lessons that incorporate manipulatives are thought to better enable students to understand mathematics concepts (Gilliland, 2002) and to develop numerical fluency (Ebdon, Coakley, & Legnard, 2003). Rec-
ommendations regarding ways to improve science education in the United States suggested that instructional strategies be designed to facilitate students’ use of realistic problems and experimentation rather than using memorization (White, 1999). In contrast, Leung (2000) noted that memorization was an important part of mathematics education in Asian countries and that students were often expected to memorize material even before the students fully understood the mathematical concepts. This cultural difference regarding the use of memorization may help to explain the differences between students in the United States and Japan that I observed in this study. Last, students in Japan who earned high mathematics test scores also indicated that they enjoyed learning mathematics whereas the same relationship was not significant in the multiple regression equation analysis for students in the United States. Therefore, on the basis of the results of this study, I suggest that there are several similarities between students in the United States and Japan for the relationship between self-beliefs and mathematics achievement. In addition, I also noted some differences in those relationships for students from the two countries.

Several relationships I observed in this study were similar to findings of previous researchers. For example, student beliefs were significantly related to several types of academic outcomes. Lynch (2002) found that students’ self-perceptions of their reading ability were significantly associated with their reading achievement whereas self-efficacy beliefs were associated with exam performance (Vrugt, Lange, & Hoogstraten, 1997). Likewise, Ma (2001) found that students’ future expectations of success exerted a significant influence on enrollment in advanced mathematics. Weiner (2000) presented a theory of motivation that considered several potential causes to which students may attribute their academic achievement, such as ability, effort, and studying strategies. In general, students who attributed their academic success to factors they thought were internal or that they controlled tended to show higher achievement levels than did students who attributed their academic outcomes to external factors (Wentzel & Wigfield, 1998). In this example, students who attributed their success in mathematics at school to natural talent or to good luck tended to show low mathematics achievement test scores. Therefore, my findings in this study indicated that students who thought that external or uncontrollable factors (natural talent, good luck) were needed for mathematics success at school also tended to show low test scores. However, students who attributed success to an internal and controllable factor (hard work studying at home) tended to earn high mathematics achievement test scores.

The relationship between student self-beliefs and mathematics achievement is critical for success and several approaches have been designed to foster positive student attitudes toward mathematics. House (2003, 2005) found that the use of cooperative learning strategies was positively related to interest in learning mathematics for adolescent students in Japan and in the United States. The development of a supportive classroom environment and the selection of effective learning examples enhanced student motivation for learning mathematics (Boyer,
Likewise, cooperative learning strategies are generally associated with improved student achievement and more favorable attitudes toward mathematics (Brush, 1997). Hannafin and Scott (2001) and Ainsa (1999) suggested that computer applications may be associated with improved student attitudes toward mathematics. For example, Hannafin and Scott showed that computer use resulted in positive student attitudes toward learning geometry. In addition, Ainsa found that the use of computer activities and manipulative materials resulted in improved number skills and interest for preschool children. Therefore, several instructional strategies exist that are related to increased student interest in mathematics and improved mathematics achievement.

One limitation of the present study is that I examined only correlations between self-beliefs and achievement. Therefore, no causal inferences about relationships between these variables can be drawn. Rather, these findings provide an initial description of those relationships for students in cross-cultural contexts. These results also provide several directions for further research. For example, additional research is needed to determine whether similar findings would be observed for students from other countries that participated in the TIMSS assessments (Beaton et al., 1996). There is also a need to determine whether the relationships between student beliefs and achievement would be similar when researchers considered the effects of instructional practices. In a study on adolescent students in Japan, House (in press-b) indicated that several mathematics beliefs were significantly associated with mathematics achievement, even after he controlled for the effects of instructional strategies. However, the results of the present study emphasize the importance of student beliefs for understanding achievement outcomes in mathematics. Furthermore, these results extend previous research findings by examining large national samples of students in cross-cultural settings as part of a comprehensive international assessment.

REFERENCES


Weiner, B. (2000). Intrapersonal and interpersonal theories of motivation from an attribu-


*Received August 31, 2005*