Pictures of Hearts and Daggers: Strong Emotions Are Expressed in Young Adolescents' Drawings of their Attitudes towards Mathematics[1]

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Enthusiasm for learning mathematics often declines in early adolescence. The Trends in International Mathematics and Science Study (TIMSS) (2003) found that 50% of fourth-graders but only 29% of eight-graders agreed strongly with the statement, "I enjoy learning mathematics." The present study explored attitudes towards mathematics through the use of adolescents' drawings and assessed the reliability and validity of drawings of math. One hundred twenty-nine U.S. students (mean age = 13.7 years) responded to these instructions, "Draw a picture of math and write about math. You can draw your feelings about math and your experiences with mathematics." Drawings were scored by independent raters according to sixteen criteria; with interrater reliability ranging from .67 to 1.00. One hundred and one students also expressed their levels of agreement on a four-point scale with the TIMSS statements about learning, valuing, and enjoying mathematics. Attitudes towards mathematics expressed in drawings significantly correlated with attitudes expressed in the TIMSS statements about mathematics. On their drawings many students expressed strong feelings about math ranging from "I absolutely love math!" to "You die math." This study demonstrated that adolescents' drawings provide a good means for assessing young adolescents' thoughts and feelings about math. The study also included comparisons of drawings of mathematics collected from 96 young adolescents from Ghana and South Africa.

1. INTRODUCTION

Motivation for learning mathematics often declines in early adolescence; this age-related phenomenon has occurred in many research contexts and is seen in the U.S.A. and internationally. A longitudinal study of 1,850 U.S. children found that self-concept of ability for math declined over the transition from sixth grade to seventh grade (Wigfield et al. 1991). A cohort sequential study of 514 children found that their ratings of interest in mathematics and their views of the importance of mathematics gradually became lower between third and ninth grades (Fredricks and Eccles 2002). Similar findings have been reported in cross-sectional studies in the U.S.A.: students' self-confidence in learning mathematics tends to be higher in elementary school years than secondary school years, the time period when the math curriculum becomes more abstract and less applicable to every day problems (Brush 1981; Geary 1994). In a cross-sectional and three year longitudinal study of 1,500 adolescents, Brush (1981) found that levels of math anxiety increased from

sixth to twelfth grades, but anxiety associated with the study of English did not increase along with grade level. In a cross-sectional study of 45 countries, the Trends in International Mathematics and Science Study (TIMSS) (2003) found that on average about 55% of fourth graders, but only 40% of eighth-graders expressed high self-confidence in learning mathematics and about 50% of fourth-graders but only 29% of eight-graders expressed high levels of enjoyment of mathematics.

Attitudes towards mathematics are important because children's self-confidence in mathematics and their valuing and enjoyment of mathematics are strongly related to their receptiveness to learning math and their subsequent achievement in math. The TIMSS study (2003) found a clear positive association between international students' attitudes towards mathematics and their mathematics achievement. In 42 of the 45 countries studied, students scoring at high levels on the valuing of math index had higher math achievement than students scoring at medium levels of valuing math. Similar associations between attitudes and achievement were reported by Hackett and Betz (1989) who found that math self-efficacy views predicted math-related educational and career choices.

In all of the studies mentioned previously, attitudes towards mathematics were assessed by children's responses to written statements about math. The present study explored the use of children's drawings to understand attitudes towards math. Unlike questionnaires with predetermined statements, drawing tasks are open-ended, unstructured, and not constrained by language. Drawings are child-centered, fun, imaginative, expressive, and engaging activities for most, though not all, adolescents. Researchers have used drawings to learn about students' general attitudes and feelings towards school (Kutnick 1978) and for cross-cultural comparisons of school classrooms (Andersson 1994; Stiles 2001). Another study by Stiles, Wilkinson and Sebben (2003) looked cross-culturally at young adolescents' attitudes toward reading as expressed in their drawings and their written responses to a questionnaire, the Elementary Reading Assessment Survey (ERAS).

Two studies have used drawings to evaluate specific educational practices. In 1995, Stiles used drawings of attitudes towards mathematics to assess the effectiveness of a mathematics improvement intervention entitled "For the Love of Mathematics." The post-intervention results from the drawings of mathematics were as follows: a significantly greater percentage of participating children (66%) than comparison group children (50%) included positive aspects in their math drawings and a significantly lower percentage of participating teachers (19%) than a comparison group of teachers (48%) included negative comments in their math drawings. In the *Evaluation Report: For the Love of Mathematics* eleven statistically significant differences between the 116 younger (7-9 years) and the 66 older (11-13 years) participating children's drawings were observed (but only one gender difference). Younger children's views toward math were more positive and less negative than older children's views (Stiles 1995). For some students thinking about math evoked strong negative feelings; this occurred even after their teachers had completed the "For the Love of Mathematics" program. Twenty percent of the young adolescents described mathematics with intense emotions - as a frightening, loathsome, and repugnant school subject (See Figure 2 for a 13-year-old boy's drawing showing an intense dislike of math).

In another study of children's perceptions of their school experiences, children's drawings were also strongly emotional and highly personal. Drawings were used to access children's specific views on high-stakes testing in Massachusetts Comprehensive Assessment System (MCAS) (Wheelock, Bebell and Haney 2000a, 2000b). Fourth, eighth, and tenth grade students in Massachusetts were invited to, "Draw a picture of yourself taking the MCAS." According to the researchers, "Students' drawings often went beyond a one-dimensional response to communicate several layers of opinion and emotion. Students coupled portraits of themselves as disheartened or bored test-takers with a critique of MCAS as 'stupid', 'too long', or 'annoying'." (Wheelock, Bebell and Haney 2000b:3).

The purpose of the present study was to access adolescents' attitudes towards mathematics through the use of their drawings and to provide evidence for the reliability and validity of drawings of math.

2. METHOD

Participants

One hundred and twenty-nine U.S. students (11-17 years) drew pictures of math and 101 of the same students also responded to written statements about self-confidence in math learning and valuing math. The sample included 52 boys (mean age = 13.7) and 77 girls (mean age = 13.7). The majority of these participants (74%) were enrolled in a suburban school district with an outstanding educational reputation and a history of high performance on standardized tests. Twenty-eight percent of the district's students are non-white and twenty-one percent are eligible for free or reduced lunch. Other participants in this study included students attending private, church-affiliated schools (18%), low-income urban schools (4%), middle income public schools (2%), and unknown (2%).

Materials

Three measures were used to evaluate math attitudes: most participants (n=125) drew pictures of math, many students wrote comments about math (n = 97) and 101 students also answered selected questions about math attitudes from the TIMSS study. All 129 participants responded to these instructions, "Draw a picture of math and write about math. You can draw your feelings about math and your experiences with mathematics." One hundred one also expressed their levels of agreement on a four-point scale with the TIMSS (2003) statements about learning, valuing, and enjoying mathematics (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree). The TIMSS index of self-confidence in learning mathematics was based on four statements: "I usually do well in mathematics. Mathematics is more difficult for me than many of my classmates. Math is not one of my strengths. I learn things quickly in mathematics." Two additional statements were concerned with valuing math: "I would like to take more mathematics in school. I enjoy learning mathematics."

Procedure

Participation was voluntary and anonymous; four students chose not to do either drawings or comments and they were excluded from the study. The data were collected by the first and fourth authors in U.S. school classrooms where the teachers and students had volunteered to participate in a variety of research projects concerning education and learning. On the questionnaires participants indicated their ages, genders, and nationalities, but not their own names.

Math drawings were scored according to fifteen categories based on a content analysis of drawings of reading (Stiles et al. 2003) and the math drawings previously collected in the "For the Love of Mathematics" study (Stiles 1995). One new scoring category was added for this study. Drawings were scored for the teacher's influence on math attitudes because it was a recurring theme in several of the drawings (see Table 1).

A sample of 28 drawings was scored by independent raters according to the sixteen criteria. Interrater reliability ranged from .67 to 1.00 (see Table 1). Other forms of reliability measures were deemed not appropriate for drawings. Because attitudes towards math can change, test-retest reliability was not evaluated.

The validity of the math drawings and scoring categories was evaluated in several ways. In addition to drawing pictures of math, adolescents also expressed their levels of agreement on a four-point scale with the TIMSS statements about learning, valuing, and enjoying mathematics. To test the validity of drawings, five categories of attitudes towards mathematics expressed in drawings were correlated with attitudes expressed in the TIMSS statements about mathematics. Further evidence for validity was acquired from comparisons of the drawings of groups who would be expected to differ on math attitudes. Previously, the math drawings of 116 younger and 66 older children were compared (Stiles 1995). In the present study, the math drawings of 25 students enrolled in an advanced/honors class were compared with those of 31 students in basic/low level classes. All U.S. drawings were scored according to sixteen categories. To further illustrate the validity of using drawings for studying math attitudes, 46 drawings from South Africa and 50 drawings from Ghana were scored for one category - profuse praise of mathematics.

3. RESULTS AND DISCUSSION

Drawings of mathematics provided a good source of information about young adolescents' views towards mathematics. Most students participated eagerly and welcomed the opportunity to illustrate their own perspectives. On their drawings many students expressed strong feelings about math ranging from "Math is wonderful!" to "You die math." (See Figure 1 for drawings showing a happy math students and Figure 2 for an example of "Math must be destroyed").

Reliability and Coding Scheme

Table 1 (next page) shows the "coding scheme", including the sixteen scoring categories, examples of each category, and interrater reliability. As can be seen in Table 1, interrater reliability is satisfactory. Other measures of reliability testing were deemed not appropriate. Experience has shown that raters of drawings can benefit from scoring a set of practice drawings first. The reliability for the category "Math interesting, intriguing, engaging" could be improved if more examples were provided to raters of drawings.

The sixteen scoring categories were based on a content analysis of children's math drawings as well as math attitudes studied by other researchers. This process assured good content validity, which in this case is the degree to which the scoring categories are representative of children's attitudes towards math.

Validity of Math Drawings

Validity, an overarching concept, is based on an accumulation of knowledge about a measure and the extent to which a measurement procedure is capable of measuring what it is purported to measure. In this study, validity was evaluated through examining the content of math drawings, the correlations between math drawings and TIMSS statements, comparisons of the math drawings of older and younger students, comparisons of the math drawings of advanced math students with basic math students, and through studying the math drawings from the U.S.A., Ghana, and South Africa.

Concurrent validity shows the relationship between drawings of math and the TIMSS statements about math. Correlations between scores on TIMSS math attitudes statements and scores on math drawings categories were used to determine concurrent validity. Table 2 shows the correlations between five of the scoring categories for the math drawings and the TIMSS index of self-confidence in learning mathematics and TIMSS statements related to valuing math. Four of the strongest correlations were negative correlations: between illustrating math as boring or tedious and not endorsing "I enjoy learning mathematics" and between including negative aspects in drawings and not endorsing enjoying math, wanting to take more math, and being self-confident in learning math. The strongest positive correlation was between loving or liking math on the drawings and having math self-

confidence on the TIMSS index of self-confidence in learning mathematics. The meaningful and statistical significant correlations provide evidence for the validity of math drawings.

Table 1. Scoring criteria and interrater reliability for scoring drawings of mathematics and comments about mathematics

Scoring Category	Examples of Category	Interrater Reliability
1. Positive aspects or tone in drawings of math	Smiley faces, exclamation points, papers with high grades	0.84
2. Positive aspects or tone in comments about math	Math is cool. Math is one of my favorite subjects.	0.72
3. Math interesting, intriguing, engaging	Students shown/described thinking about math, raising their hands	0.67
4. Math relevant, useful, worthwhile	You can get far in life with math. I will need math for my job.	1.00
5. Love, like, enjoy math	Pictures of hearts. I like math. Math is enjoyable.	1.00
6. Math is fun	We have a good time in math class. Math is super fun.	1.00
7. Profuse praise of math	I absolutely adore math! Superlatives, exclamation points, multiple aspects praised	1.00
8. Negative aspects or tone in drawings of math	Worried faces, frowns, no math signs	0.92
9. Negative aspects or tone in comments about math	I don't like math. I would rather eat my pen than have math.	1.00
10. Math boring, tedious	Depictions of sleep, snoring, yawning. It's a waste of time.	0.92
11. Math frightening, loathsome, repugnant	Weapons directed against math. I hate math! Math operations stabbed by daggers	1.00
12. Mixed or ambiguous view of math	I like geometry, but I don't like algebra. Smiles, frowns, and confused expressions: Math is okay, but...	0.79
13. Math is easy, not difficult.	Math is described as easy and/or simple, easy, basic arithmetic is shown 2 + 2 = 4	0.85
14. Math is hard, difficult	Math is described as a hard subject and/or difficult, complex or advanced math is shown - geometry, algebra	0.83
15. Math comments lengthy	Descriptions of more than 40 words	1.00
16. Teacher mentioned or shown	I like math when I have a good math teacher.	1.00

A method of measuring convergent validity is to look at the differences in scores between contrast groups of people who would be expected to score differently on a measure of math attitudes. Several studies would predict more positive math attitudes for younger children compared with older children (Brush 1981; Fredricks and Eccles 2002; TIMSS 2003; Wigfield et. al. 1991). Eleven statistically significant differences between younger and older children's drawings of math were reported in the *Evaluation Report: For the Love of Mathematics* (Stiles 1995); consistently, younger children were more positive than older children were. According to TIMSS (2003), higher math achievement should be associated with more favorable math attitudes and lower math achievement with less favorable attitudes.

In the present study using math drawings, four statistically significant differences were found between high achieving, advanced math students and low achieving, basic math students. Differences in several categories only approached statistical significance. Perhaps the two contrast groups were more similar to each other than they would have been at another school because the teachers of both the advanced and the basic classes seemed to foster positive attitudes in both groups. According to chi-square tests, students in the advanced class drew more positive pictures of math than students in basic class did (X^2 (1, N = 56) = 7.39; $p < 0.01$); students in the advanced class described more loving and liking of math than students in basic class did (X^2 (1, N = 56) = 17.93, $p < 0.001$); students in the advanced class described math as more hard and difficult than students in the basic class did (X^2 (1, N = 56) = 3.99, $p < 0.05$); and students in the advanced class drew more mixed or ambiguous pictures of math than students in the basic class did (X^2 (1, N = 56) = 15.61, $p < 0.001$). The findings in the present study agreed with TIMSS (2003), a study which also found that high achieving students compared with low achieving students had more positive math attitudes and were more likely to view math as a hard and difficult subject.

Table 2. Correlations between math drawings and TIMSS statements

	Self-confidence in Learning Math Index	Enjoy Math	Take More Math
positive drawings	0.25*	0.20	0.16
negative drawings	-0.29**	-0.35***	-0.30**
love/like math	0.33***	0.26**	0.24*
relevant, useful	0.19	0.12	0.22*
boring, tedious	-0.04	-0.30**	-0.12

* = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$

Figure 1 and Table 3 show positive views of math by adolescents from the U.S.A. Figure 2, "Happy About Math, Happy Time" was drawn by a 14-year-old girl in an honors/advanced math class. This girl also strongly agreed with the statement, "I usually do well in mathematics" and she wrote on her drawing, "When I understand and get math, then I like and enjoy it. But, when I don't understand it, then it is not always enjoyable." The smiling face below was drawn by a 15-year-old boy in an honors/advanced math class. This boy also strongly agreed with the statement, "I usually do well in mathematics" and he wrote next to his drawing, "Math is fun for me because it helps me understand things better, like going to a grocery store & understanding that 18 oz. for $1.99 is a better deal then 16 oz. for $2.49."

Figure 1:

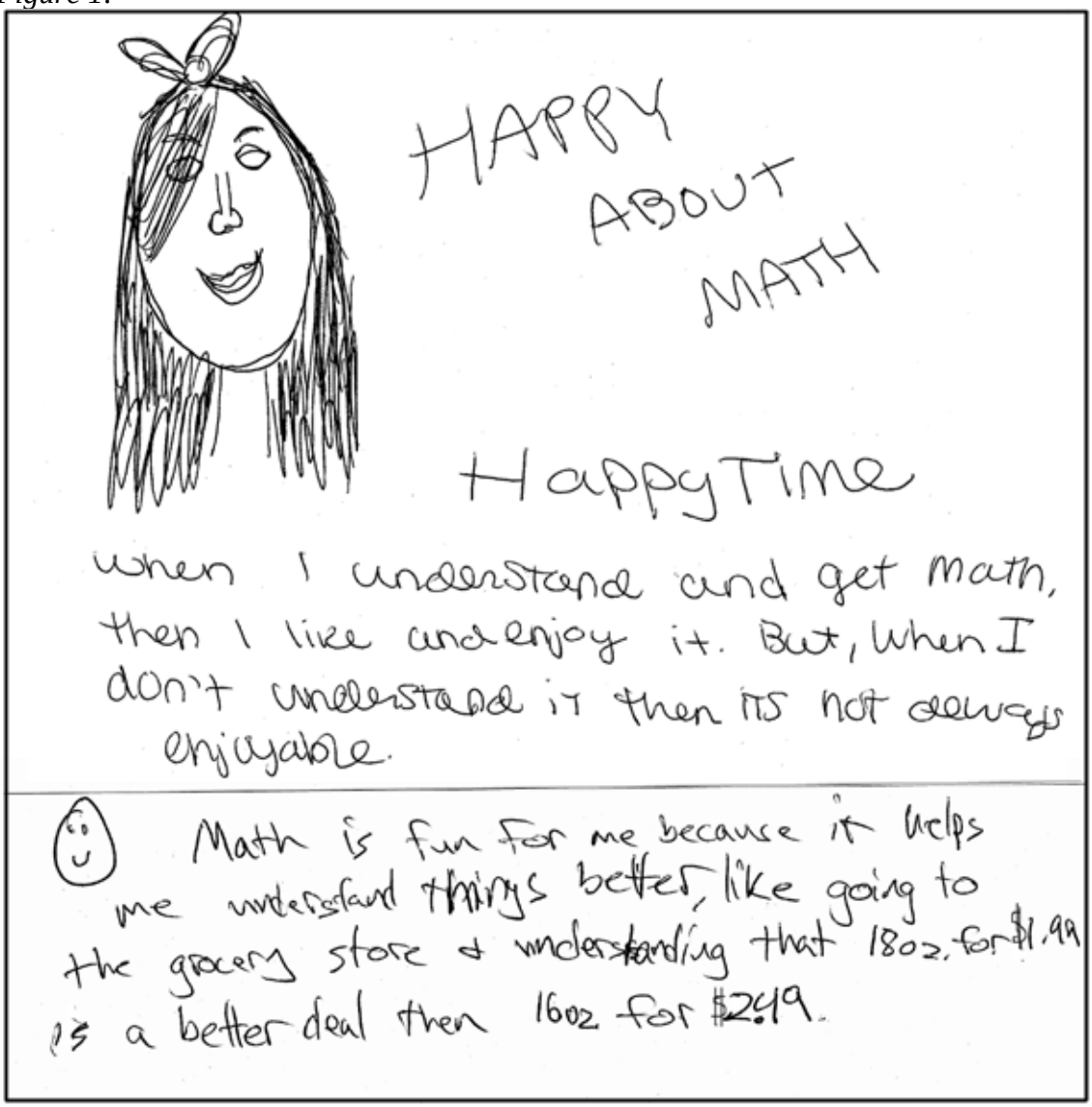


Table 3 shows positive views of math, frequency of occurrence and evidence of validity for seven scoring categories. As illustrated in Table 3 less than half (41.9%) of the drawings had positive elements or a positive tone and slightly less than half (48.8%) of the comments had positive elements or a positive tone. The response to "I enjoy learning mathematics" was slightly more favorable than unfavorable. On a four point scale with four equaling strongly agree and one equaling strongly disagree, 10.5% strongly agreed with the statement (M = 2.87, SD = 0.66). These results suggest that about half of young adolescents have a somewhat favorable view towards math.

Table 3. Positive views of math, frequency of occurrence, and evidence of validity

Category	Percentage	Evidence of Validity of the Category
1. Positive aspects or tone in drawings of math	41.9	Positive attitudes towards math are associated with higher math achievement (Hackett and Betz 1989; TIMSS 2003) Younger children's drawings more positive than those of older children, $p < 0.05$ (Stiles, 1995). Drawings of students in advanced math classes more positive than those of students in basic math classes, $p < 0.01$. Positive drawings correlated with having high self-confidence in learning math, $p < 0.05$.
2. Positive aspects or tone in comments about math	48.8	Younger children's comments more positive than those of older children, $p < 0.01$.
3. Math interesting, intriguing, engaging	14.0	Similar to the findings of Fredricks and Eccles 2002), younger children's drawings show more interest in math than those of older children, $p < 0.05$.
4. Math relevant, useful, worthwhile	10.1	Math depicted as relevant and useful correlated with the desire to take more math, $p < 0.05$.
5. Love, like, enjoy math	27.9	Similar to the findings of TIMSS (2003), the drawings of students in advanced math classes expressed loving or liking math more often than students in basic math classes, $p < 0.001$. Enjoyment on math drawings correlated with positive math attitudes, $p < 0.05$.
6. Math is fun	12.4	
7. Profuse praise of math	3.9	When compared to the USA, adolescents from Ghana and South Africa were more enthusiastic about math on a math attitudes survey and also more likely to profusely praise math on their math drawings, $p < 0.001$.

Table 4 and Figure 2 illustrate negative views in U.S. drawings of math. In Figure 2 "Math must be destroyed." In this drawing by a 13-year-old boy, math is being attacked with a machine gun and subtraction, multiplication, and division are being stabbed.

Table 4 shows negative views of math, frequency of occurrence and evidence of validity for four scoring categories. As illustrated in Table 4 less than half (38.8%) of the drawings had negative elements or a negative tone and less than half (42.6%) of the comments had negative elements or a negative tone.

Table 5 and Figure 3 show mixed and neutral views of math reflected in drawings, frequency of occurrence and evidence of validity for five scoring categories. As illustrated in Table 5, 41% of the drawings had mixed neutral or ambiguous views of math. Opinions about mathematics don't always belong on a continuum ranging from strongly disagree to strongly agree. In their drawings, 41% of adolescents qualified their responses and explained when they liked math and when they didn't. Drawings of math are able to capture nuances and complexities of adolescents' views.

Figure 2:

Table 4. Negative views of math, frequency of occurrence, and evidence of validity.

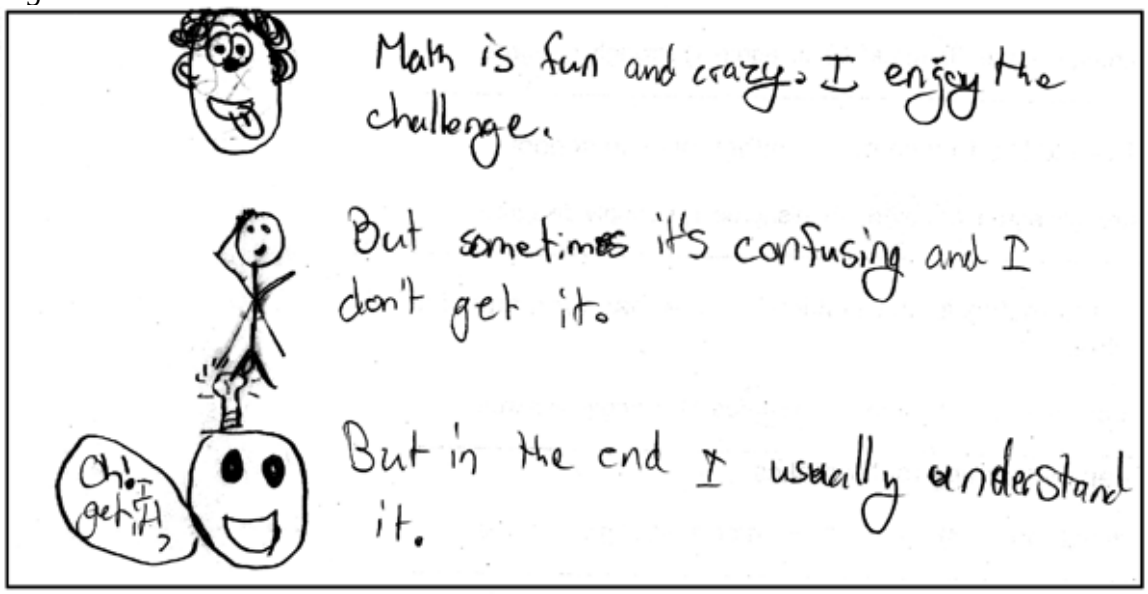
Category	Percentage	Evidence of Validity of the Category
8. Negative aspects or tone in drawings of math	38.8	Similar to the findings of Brush (1981), younger children's drawings were less negative than those of older children, $p < 0.01$. Students with more negative elements in drawings less likely to want to take more mathematics, $p < 0.01$, be self-confident in math, $p < 0.05$, and enjoy math, $p < 0.001$. Students in advanced math classes' drawings more positive than those of students in basic math classes, $p < 0.05$.
9. Negative aspects or tone in comments about math	42.6	Younger children's comments less negative than those of older children, $p < 0.001$.
10. Math boring, tedious	18.6	Younger children think math is less boring math than older children, $p < 0.01$. Thinking that math is boring negatively correlated with enjoying math $p < 0.001$.
11. Math frightening, loathsome, repugnant	6.2	Younger children think math is less frightening, loathsome, and repugnant math than older children, $p < 0.01$.

Table 5. Mixed, ambiguous and neutral views of math, frequency of occurrence, and evidence of validity.

Category	Percentage	Evidence of Validity of the Category
12. Mixed or ambiguous view of math	41.2	Younger children's drawings less mixed than those of older children, $p < 0.001$ Drawings of students in advanced math classes more mixed than those of students in basic math classes, p <0 .05.
13. Math is easy, not difficult.	7.0	Younger children more likely to show math as easier than older children p <0 01
14. Math is hard, difficult	29.5	Similar to the findings of TIMSS (2003), advanced math students described math as hard. Younger children less likely to show math as hard than older children p <0 001
15. Math comments lengthy	3.9	
16. Teacher mentioned or shown	17.1	Teachers make a difference in math attitudes (Geary 1994; Wigfield et al. 1991).

Figure 3 shows a 14-year-old girl's drawing of math. First she describes math as "fun and crazy", then she scratches her head ("sometimes it's confusing"), and finally the light bulb ("In the end I usually understand").

Figure 3:



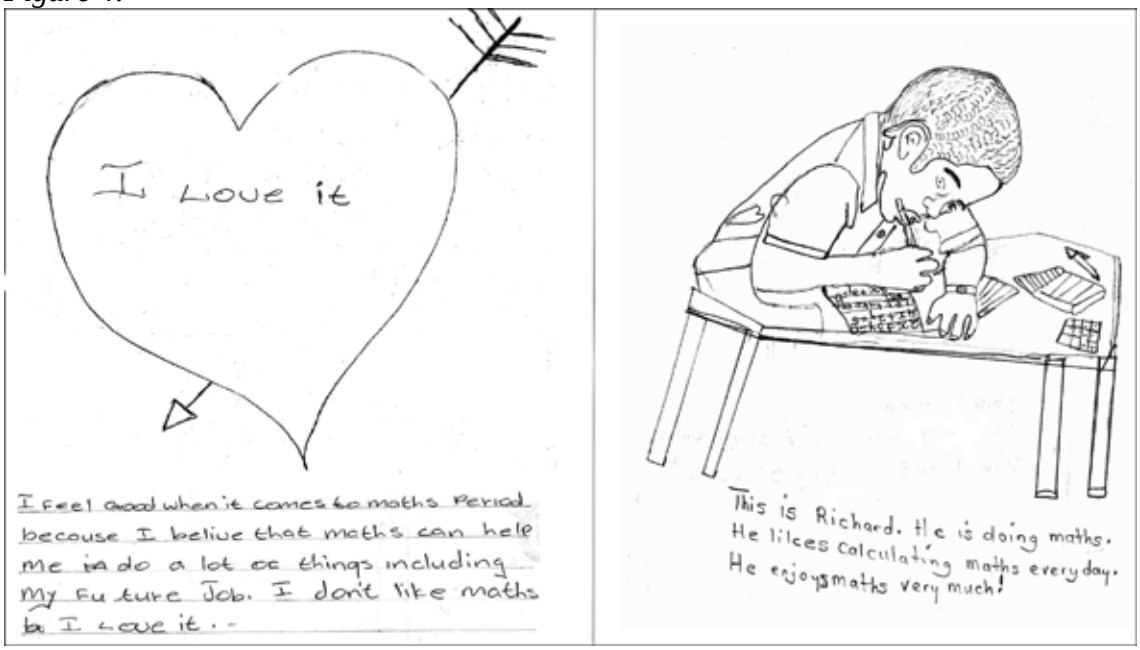
Cross-Cultural Applications

Thus far, math drawings have been collected from three countries participating in the TIMSS studies: Ghana, South Africa and the USA. In these three countries there were variations in math attitudes and math achievement, but a consistent positive association between students' attitudes and their mathematics achievement. When the achievement scores of students having high levels of valuing math were compared with those having medium levels of valuing math, they were consistently higher; 293 compared with 227 for Ghana, 271 compared with 243 for South Africa, and 512 compared with 498 for the U.S.A. In fact, in

42 of the 45 of the TIMSS countries, students showing the highest levels of valuing mathematics had higher achievement scores than those with medium levels in their respective countries. In the TIMSS study more students from Ghana and South Africa expressed high enthusiasm for the importance of math. Larger proportions of adolescents from Ghana (82%) and South Africa (79%) expressed high levels of valuing mathematics than in the U.S.A. (58%). Similarly, on adolescents' math drawings, significantly larger proportions of adolescents from Ghana (22%) and South Africa (23.9%) expressed profuse praise of math than in the U.S.A. (3.9%). Chi-square-tests revealed that these differences were highly significant. (X^2 (2, N = 225) = 18.98; $p < 0.001$). These results further underscore the validity of math drawings; high enthusiasm for valuing math on TIMSS statements is associated with profuse praise of math on drawings.

Figure 4 shows examples of profuse praise of math from Ghana and South Africa. On the left is a drawing by a 15-year-old boy from South Africa. He wrote, "I don't like maths – I love it." On the right is a drawing by a 16-year-old girl from Ghana. She drew Richard and wrote, "He enjoys maths very much!" These results from Ghana and South Africa suggest that math drawings are open-ended and can provide valuable insights into a cross-cultural study of math attitudes.

Figure 4:



4 CONCLUSIONS

A limitation of using math drawings is that not all adolescents express themselves fully when they are asked to do drawings and write comments about math. Four students chose not to do any drawings or comments and several students' drawings were not elaborated fully. Because the students did the drawings anonymously and independently, it was not always possible for the raters of drawings to decipher the exact intent of the drawer.

The majority of participants in this study welcomed the invitation to, “Draw a picture of math and write about math. You can draw your feelings about math and your experiences with mathematics”. In most instances their drawings and comments were thoughtful and detailed. This study has provided ample evidence for the reliability and validity of using drawings of math to learn about adolescents’ attitudes towards mathematics. In terms of accessing students’ views, math drawings were shown to be superior to the TIMSS math statements. Math drawings allow for stronger responses and more individual expression; for example, disagreeing with the statement “I enjoy learning mathematics” is not as strong as drawing a picture showing math being destroyed with weapons. Drawings allowed students to express qualified, ambiguous, and mixed viewpoints. Drawings of math were able to capture the complexities of adolescents’ views, not easily accessed by rating scales.

Attitudes towards math are important; it has been shown that high math achievement is strongly related to having positive attitudes towards math. Students who have developed an intense dislike of math may not be receptive to math teaching. In this study 19% drew or described math as boring and only 10% depicted math as useful, relevant, or worthwhile. Teachers can use math drawings and math attitudes surveys to access their students’ ideas and to learn how successful they are being in instilling an interest in math and self-confidence in learning math. One seventh and eighth grade teacher, who is currently using math drawings to better understand her students, plans to continue to evaluate her students’ perspectives throughout the year (Barbara Telhorst, personal communication, October 11, 2005). Math drawings can also be used for research purposes and they may be especially valuable for cross-cultural research.

5. NOTES

1. Paper and poster presented at the 2006 Hawaii International Conference on Education, January 6-9, 2006.

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