International Teachers' Judgment of Gifted Mathematics Student Characteristics

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Abstract

Teachers play a key role in the identification and training of talented mathematicians, and their attitudes are important in improving math instruction for gifted students. We surveyed secondary mathematics teachers from South Korea, Turkey, and the United States. These teachers completed a survey instrument called the Teachers' Judgments of Gifted Mathematics Student Characteristics (TJGMSC) that measured how important they believed 40 behaviors were with regards to students' mathematics giftedness. They also evaluated different strategies for teaching mathematics. The more years teachers taught mathematics, the more likely they were to report that students' computational skills, students' ability to relate mathematics to everyday life, and students' ability to generate multiple and unique solutions to problems were indicators of mathematical talent. The opposite was true for the highest level of mathematics taught. The higher the grade level of mathematics teachers taught, the less they valued each of these. Teachers with advanced degrees were less impressed with computation skills. Teachers from South Korea, whose students score near the top on international mathematics exams, were less likely to view mathematical talent as innate. They saw mathematics as an abstract subject in which students who were having difficulty should be given time in class to practice by themselves. They were less likely to regard mathematics as a practical topic or a formal way of representing the world. They were also less likely to use a variety of representations (pictures, concrete objects, and symbols) when teaching mathematics.

Keywords: Mathematics instruction, mathematics aptitude, secondary education, gifted and talented, international studies.

Introduction:

The National Research Council (1989) stated that mathematics is essential for employment in the new world economy. The new work force needs the problem-solving skills of absorbing new ideas, adapting to change, coping with ambiguity, and perceiving patterns. Basic calculation skills are now insufficient with the ubiquitous availability of calculators and computers. Students need mathematical skills in problem solving and critical thinking in order to be marketable in a highly competitive high-tech job market. They should also be confident in their mathematical abilities and in their abilities to use mathematical skills to confront new problems (Borasi, 1996). For a country to be a leader in the high-tech global economy it must develop the mathematic talents of its citizens. This involves identifying and serving students who show talent in mathematics. Nations must invest in the education of well-trained mathematicians and engineers (National Commission on Excellence in Education, 1983).

Teachers play a key role in the identification and training of talented mathematicians. Teachers' gender, experience, education, culture, perceptions, and expectations may influence how well they identify and train mathematically gifted students (Greenes & Mode, 1999; Keynes, Olson, Shaw, & Singer, 1999; Reis & Gavin, 1999). It is important, therefore, to study these variables. For example, within the United States a debate exists over which mathematical skills ought to be valued (National Council of Teachers of Mathematics, NCTM, 2000). Just as there are differences of opinion within the United States, the particular mathematical skills valued by teachers may vary from one culture to another.

Research Questions

In this study we surveyed secondary mathematics teachers from South Korea, Turkey, and the United States. The following research questions guided our research:

1. What are the demographic characteristics (gender, highest degree earned, certification in math, years of experience teaching math and other subjects, and current and highest level of teaching mathematics) of secondary school mathematics teachers in South Korea, Turkey, and United States?
2. Is there a relation between the demographic characteristics of teachers and their ratings of the characteristics of mathematically gifted students?
3. Are there any differences among mathematics teachers from South Korea, Turkey, and United States in terms of their ratings of the characteristics of mathematically gifted students?
4. Are there any differences among mathematics teachers from South Korea, Turkey, and the United States in terms of their views about mathematics and the teaching of mathematics?

Background

Mathematics Achievement of South Korea, Turkey, and United States

The 1995 Third International Mathematics and Science Study (TIMSS) was the largest, most comprehensive, and most rigorous international comparison of education ever undertaken (National Center for Educational Statistics, NCES, 1996). During 1995, the study assessed the mathematics and science knowledge of a half-million students from 42 nations at three levels of schooling. The Third International Mathematics and Science Study–Repeat (TIMSS–R) followed in 1999 (NCES, 2000). The 1999 assessment measured the mathematics and science achievements of eighth-grade students (13- and 14-year-olds). Extensive information was collected from students, teachers, and school principals about mathematics and science curricula, instruction, home contexts, and school characteristics and policies. The United States and South Korea participated in 1995 and in 1999. Turkey participated only in 1999. The results, generally, were alarming to the United States.

- U.S. fourth graders scored only slightly above the international average (NCES, 1997).
- At the eighth-grade level, U.S. students fell slightly below the international average (NCES, 1996).
- U.S. performance continued to fall in the twelfth-grade assessment where the U.S. students scored significantly below the international average (NCES, 1998).
- No country scored below the U.S. on the advanced mathematics assessment (NCES, 1998).
- In TIMSS-R eighth graders from Turkey scored significantly below the U.S. eighth graders (IEA, 2000).
- South Korean eighth graders scored second among 42 nations (NCES, 1996).

We chose the three countries for this study because their students exemplified different levels of mathematics achievement in this international data. Generally, students from the United States achieved lower than students from South Korea, but higher than students from Turkey.

Identification of Gifted Mathematicians

Various attempts have been made to identify the characteristics of mathematically gifted students (Greenes, 1981; Heid, 1983; House, 1987; Lester & Shroeder, 1983; Osborne, 1981; Sheffield, 1994; Waxman, Robinson, & Mukhopadhyay, 1996). Above-level testing is sometimes used to identify precocious mathematical ability. A high score at an early age on a mathematics aptitude test indicates mathematical talent (Stanley & Benbow, 1986). One of the best-known mathematics programs for gifted children is the Study of Mathematically Precocious Youth (SMPY). It was founded by Julian C. Stanley at Johns Hopkins University in 1971 to identify, study, and facilitate the education of youths who reason mathematically extremely well (Stanley, Keating, & Fox, 1974). SMPY uses above-level testing with the Scholastic Aptitude Test (SAT) to identify precocious mathematical ability and designs rigorous academic coursework to challenge high-scoring students (Stanley & Benbow, 1986).

The tests are selected for several reasons. They focus on mathematical reasoning rather than learned mathematical facts and do not have a ceiling for young children. The scoring system can be compared to different tests. The tests are easy to administer and cost effective because they are administered to a group, rather than individually (Hoeflinger, 1998; Kissane, 1986;

Rotigel & Lupkowski-Shoplik, 1999; Sheffield, 1994). Longitudinal research with SMPY students showed the SAT was predictive of later advanced achievement (Lubinski & Benbow, 2006). On grade-level testing also is used. The Test of Mathematical Abilities for Gifted Students (TOMAGS; Ryser & Johnsen, 1998) is a standardized, norm-referenced test designed to identify students who are gifted in mathematics. A test such as the TOMAGS is considered superior to traditional standardized achievement tests because typical standardized achievement tests often concentrate on low-level tasks that fail to identify gifted students (Romberg & Wilson, 1992).

Teacher nominations are often used in the identification of students with exceptional talent—a process debated for decades (Gagné, 1994; Hoge & Cudmore, 1986; Pegnato & Birch, 1959; Rohrer, 1995). Pegnato and Birch (1959), when examining the efficiency and effectiveness of seven different methods of identifying gifted students, concluded teachers are not reliable in this regard. The Pegnato and Birch study was referenced as proof of teachers' inability to identify gifted students in their classrooms for over four decades. However, slightly over a decade ago, Gagné (1994) reported that Pegnato and Birch's methods were unreliable. Furthermore, after reevaluation of data from the study, Gagné concluded teachers are actually as reliable as most other sources of information.

Other studies have also shown teachers can identify gifted students reliably. Hoge and Cudmore (1986) found very little empirical evidence exists to support a negative evaluation of teacher judgments. Rohrer (1995) found, in general, teachers are able to recognize intellectual potential in students not in the mainstream. Borland (1978) found identification improved when teachers were provided with specific criteria to use when identifying students. Other studies have found this to be true. Gender bias (Powell & Siegle, 2000) and student interest areas (Siegle & Powell, 2004) are areas of concern in identifying students for gifted programs when specific criteria are not provided.

Unfortunately, mathematics teachers generally do not have background in teaching gifted students. According to Sheffield (1999), teachers should ideally receive training and experience in both the complexities of mathematical content and, particularly, in the characteristics and needs of gifted students, prior to evaluating students for mathematical giftedness. In some states, elementary teachers might be certified to teach all subjects from K-8 but have little background in mathematics after taking only one or two university-level mathematics courses. Secondary school teachers generally major in mathematics at the university while receiving little or no training in talent identification.

The Scales for Rating Gifted Students (Ryser & McConnell, 2004) and the Scales for Rating the Behavioral Characteristics of Superior Students (Renzulli, Smith, White, Callahan, Hartman, & Westberg, 2004) are two popular rating scales to identify mathematically gifted students. These commonly used rating scales are based on published characteristics of mathematically talented students.

Characteristics of Mathematically Talented Students

Mathematically gifted students have complex types of reasoning skills. Unfortunately the reasoning abilities associated with high ability in mathematics are often underemphasized, and computational accuracy and conformity to taught procedures are overemphasized. Lupkowski-Shoplik and Assouline (1994) noticed many mathematically gifted children are advanced in their understanding of mathematical concepts but relatively weak in mathematical calculations. Mathematically gifted children may conceptualize problems and solutions correctly even though they may make computational errors (Miserandino, Subotnik & Ou, 1995).

Mathematically gifted students also have an unusually keen awareness of, and intense curiosity about, numeric information (Miller, 1990). They develop unique solutions to common problems (Wolfle, 1986) and interpret problem information in original ways (Greenes, 1981). They work with mathematical problems in flexible, creative ways rather than in a stereotypic fashion (Miller, 1990). Mathematically challenging problems give these talented children an opportunity to shine. Mathematically gifted children make unique associations when presented with a challenging problem (Chang, 1985). Krutetskii (1976) also believed mathematically gifted children have a "mathematical cast of mind" disposed toward interpreting the world mathematically. They have a tendency to see mathematics in the ordinary and commonplace (Osborne, 1981).

Mathematically gifted children ask mathematics-related questions that go beyond clarification (Miserandino, Subotnik, & Ou, 1995). They have a capacity to go beyond the answer to a particular problem and field questions that the answer itself raised (Marjoram, 1992). They are unwilling to accept statements without critical examination to find the "whys" and "hows" (Wolfle, 1986). They criticize constructively, sometimes argumentatively (Wolfle, 1986).

Hoeflinger (1998) reported that when a genuine problem is presented, mathematically gifted students have the ability to experience true problem solving tasks by internalizing, reshaping, and questioning. This involves applying multiple strategies to move forward the process of solving problems.

Results of a study by Olszewski-Kubilius, Shaw, Kulieke, Willis, and Krasney (1990) suggested previous experience and exposure to mathematics are important predictors of success in accelerated mathematics classes, especially for gifted females. Previous experience and exposure is acquired through independent activities such as participation in math clubs, tutoring, and parental teaching at home. These activities evidently give both mathematically talented females and males an advantage. They provide opportunities for students to increase in both abstract reasoning skills and specific mathematical knowledge. Math clubs and parental teaching may therefore be important factors in the talent development process.

Teachers' observations of students involved in a mathematical problem solving process and its associated discussion can be an accurate and reliable tool for identifying gifted young students (Gavin et al., 2007). Through this process students show how they organize knowledge, communicate ideas, and make convincing arguments (Hoeflinger, 1998). Teachers should look for strategies, efficiency, and elegance as well as pace during the identification process. Wilson and Briggs (2002) suggested observing children at work and using audio and video recordings, presentations, and displays of work to support assessments. To maximize the numbers of students involved, several opportunities should be available requiring no formal identification process such as investigating challenging, open-ended problems during mathematics classes, joining mathematics clubs, entering mathematics contests, and using technology to find and discuss engaging problems or to meet mentors or peers with similar interests (Sheffield, 1999).

According to Krutetskii (1976), talent is not a single characteristic but rather a qualitative combination of different abilities unique for each person. Not all mathematically gifted students will have all the attributes listed above. A student may possess only some of the characteristics.

Method

Instrumentation

We developed a survey instrument called the Teachers' Judgments of Gifted Mathematics Student Characteristics (TJGMSC) to collect data for this study. Items from the preliminary version of the SRBCSS-Math Scale (Renzulli et al., 2004) formed the basis of the survey instrument. We added 20 additional characteristics to the survey. These were based on one of our experiences teaching mathematics in Turkey and the United States. We field tested the 40-statement instrument with a group of 95 preservice education majors and summer school graduate students in gifted education in the United States. The teachers read each statement and indicated how important they believed the behavior was with regards to students' mathematics giftedness. Teachers rated the characteristic on a 5-point Likert scale *(1=Unimportant, 2=Of Little Importance, 3=Moderately Important, 4=Important, and 5=Very Important).* After the field test, minor wording changes were made in a few items, but all of the items were retained.

In addition to these 40 items, we reviewed the TIMSS-R Mathematics Teacher Questionnaire. We selected 15 closely related items from TIMSS-R Mathematics Teacher Questionnaire. Six of these items related to student characteristics and were added to the 40 items previously field tested. We added another nine items from TIMSS-R Mathematics Teacher Questionnaire to create a second section of the survey. In this section, teachers rated their view about mathematics and teaching mathematics on a 4-point Likert scale *(1=Strongly Disagree, 2=Disagree, 3=Agree,* and *4=Strongly Agree)*. The statements in both survey sections were closed-ended to facilitate data analysis (Gall, Borg, & Gall, 1996).

The final TJGMSC survey contained four pages. The teacher information section contains eight items providing information about a teacher's background. These items include descriptive demographic data on each teacher (gender, highest degree earned, subject area(s) taught, certification in math, years of experience teaching math and other subjects, and current and highest level of teaching mathematics). The first section contained 46 items covering gifted mathematics students' characteristics. The second section included nine items measuring teachers' views about mathematics and teaching mathematics.

Following the field test, the final survey and instructions were translated into Turkish by one of the researchers. A qualified bilingual Turkish mathematics teacher translated the Turkish translation from Turkish back to English. The Turkish to English translation was compared to the original English version. All statements were closely matched, and we accepted the Turkish translation as comparable to the English version of the survey.

Similarly, the final survey and the instructions were translated into Korean by a South Korean researcher. Another South Korean researcher translated that translation from Korean back to English. All statements closely matched, and we accepted the Korean translation of the survey as being comparable to the English version. Since all the mathematics teachers are certified in South Korea, questions about certification were omitted from the Korean version of the survey.

We sampled 900 high school mathematics teachers from South Korea, 408 high school mathematics teachers from Turkey, and 1000 high school mathematics teachers from the United States. A South Korean researcher cluster sampled 900 secondary mathematics teachers. The surveys were sent to 180 high schools in South Korea. Five surveys were sent to each high school. A total of 296 teachers from 65 high schools returned the surveys. The sample consisted of 33 high schools in metropolitan cities, 18 high schools in small cities, 4 high schools in rural areas, 6 science high schools for gifted students, and the Korean Minjok Leadership Academy for gifted students. The type and location of 3 high schools were not reported.

A Turkish sample of 408 high school mathematics teachers was selected from a list provided by the Turkish Ministry of Education, Educational Research and Development Directorate (ERDD). These teachers were teaching in 25 cities that included metropolitan cities, small cities, and rural areas in seven different geographic regions of the country. This sample included teachers from different types of high schools. In Turkey, there are many types of high schools: public, private, regular, vocational, and science high schools. The Turkish sample included all types of high schools. Of all the surveys sent out and collected by the ERDD, 389 were complete.

In the United States, we randomly sampled 1000 mathematics teachers using a Market Data Retrieval (MDR) list of high school mathematics teachers. MDR is a national company that compiles categorized lists of names and addresses to sell for research purposes. We received a total of 262 surveys from two mailings. All participants were provided with a cover letter explaining the study and a survey. In the United States, the teachers mailed the completed surveys to the principal investigators in postage paid envelopes.

In South Korea, with only one mailing, the return rate was 33%. In Turkey, with only one mailing the return rate was 95%. The higher return rate for Turkey was because it was sent through the Turkish Ministry of Education. In United States, the return rate was 19% after the first mailing and 26% after the second mailing.

Table 1 shows the number of teacher respondents to TIMSS-R Mathematics Teacher Questionnaire in 1999 and to our TJGMSC survey in 2003.

Upon collection of the data, a factor analysis with a varimax rotation was performed on the 46 gifted mathematics student characteristics items to determine if an appropriate set of subscales could be found. Most teachers responded to all items on the survey. In the event a teacher left an item blank, it was listwise deleted. The analysis produced a nine-factor solution. An examination of factor loadings and the distribution of the items by factor resulted in the selection of three of these factors. This three-factor solution accounted for 42% of the variance on the gifted mathematics student characteristics statements in our survey. These factors were labeled as follows: School Smart Mathematics Students (students with excellent arithmetic skills), Mathematics Perspective for the Real World (students who relate mathematics

Table 1: Sample sizes comparison with TIMSS-R.

S.Korea		Turkey		USA	
TJGMSC	TIMSS	TJGMSC	TIMSS	TJGMSC	TIMSS
296	193	389	204	262	462

Note: TIMSS-R 1999 International Average sample size=196.

Table 2: lists the gifted mathematics student characteristics for each factor and their reliability analysis.

Item	Factor loading
Factor 1: School Smart Mathematics Students (α= .901)	
27. displays ability to do calculations accurately.	.815
40. has good memory recall.	.813
41. remembers formulas and procedures.	.793
28. has ability to do calculations quickly.	.772
38. earns high scores in math/quantitative test(s).	.731
42. thinks in a sequential and procedural manner.	.667
43. understands mathematical concepts, principles, and strategies.	.601
Factor 2: Mathematics Perspective for the Real World (α= .882)	
24. relates math to everyday life.	.696
23. can see the world through a math lens.	.652
45. understands how mathematics is used in the real world.	.561
36. makes connections between math and other subject areas.	.553
13. looks at the world from a mathematical perspective.	.542
20. sees the connections between different areas of mathematics.	.521
22. can explain concepts in math terms.	.498
46. is able to provide reasons to support their solutions.	.461
14. displays a strong number sense	.448
21. can distinguish relevant and irrelevant information in math problems.	.444
16. asks high-level questions such as "why" or "what if" that increase the depth and complexity of the mathematics being studied.	.433
15. displays an interest in analyzing the mathematical structure of a problem.	.423
Factor 3: Creative Problem Solver (α= .840)	
44. is able to think creatively.	.746
31. generates new ways to solve problems.	.714
4. has creative (unusual and divergent) ways of solving math problems.	.592
33. offers different solutions to one problem.	.589
39. generates many ideas, solutions, explanations, etc.	.557
30. has ability to incubate when s/he cannot solve the problem immediately.	.521
26. has spatial/3D ability.	.440
37. enjoys solving challenging problems.	.431

to everyday life), and Creative Problem Solver (students who generate a variety of possible solutions to problems). Alpha reliabilities for the factors were .901, .882, and .840 respectively.

We calculated a composite score for each factor based on the mean of the statements within each factor. Histograms revealed the composite scores for the three factors were negatively skewed. We approximated a normal distribution for each factor with natural log transformations.

Participants

A majority of the high school mathematics teachers were male in South Korea and Turkey, while gender was fairly evenly split in the United States (see Table 3). The majority of U.S. teachers held Master's degrees while most Turkish teachers held Bachelor's degrees. South Korean teachers were somewhat split between having an undergraduate degree and having a graduate degree (see Table 3). Some of the Turkish teachers held a degree from a 3-year education institute, and they were coded as if they held a Bachelor's degree.

All of the teachers in South Korea and Turkey reported they only taught mathematics. Only a small percentage, 0.4% of the United States teachers taught a subject other than mathematics. All South Korean mathematics teachers were certified in mathematics. Turkey and the United States had small percentages of non-certified mathematics teachers, 0.8% and 2.9%, respectively.

The number of years of teaching experience in South Korea, Turkey, and in the United States ranged from 0 to 35, 1 to 34, and 0 to 43, respectively (see Table 4). Sixteen percent of the United States mathematics teachers had more than 30 years of experience while less than 1% of the South Korean and Turkish mathematics teachers had more than 30 years of experience.

Table 3: Teacher demographic information reported as percentages for gender and highest degree held by country.

	South Korea *n*=296	Turkey *n*=389	USA *n*=262	Total *N*=947
Gender				
Female	33.9	41.9	51.3	41.8
Male	66.1	58.1	48.8	58.2
Highest Degree of Education				
Bachelors	55.7	93.6	39.5	66.6
Masters	41.6	6.4	59.3	32.2
Sixth Year	0.0	0.0	0.4	0.1
Ph.D.	2.7	0.0	0.8	1.1

Table 4: Years of experience teaching (All) and years of experience teaching mathematics (Math).

Years	South Korea *n*=296		Turkey *n*=389		USA *n*=262	
	All	Math	All	Math	All	Math
0 – 5	26.7	23.8	11.4	12.4	13.0	18.3
6 – 10	11.0	13.3	24.8	24.0	18.8	18.3
11 – 15	21.2	22.1	20.1	19.9	14.6	14.4
16 – 20	18.8	18.7	12.4	13.2	12.2	10.9
21 – 25	11.3	12.2	23.3	23.3	7.3	6.6
26 – 30	10.3	8.2	7.5	6.9	16.9	15.5
31 – 35	0.7	0.7	0.5	0.3	13.8	12.5
36 – 40	0.0	0.0	0.0	0.0	2.6	2.7
41 – 45	0.0	0.0	0.0	0.0	0.8	0.8

Results

Data were entered into a series of stepwise multiple regression procedures to assess the relation between the demographic characteristics of the teachers and their ratings of the characteristics of mathematically gifted students. The predictor variables, gender (dummy coded), years of experience teaching mathematics, highest level of teaching mathematics (9-12), and highest degree earned (codes 1-5) were measured through completion of the personal information section of the Teachers' Judgments of Gifted Mathematics Student Characteristics survey by the 947 high school mathematics teachers from South Korea, Turkey, and United States. The criterion variables were the natural log transformed composite scores for the three factors from our survey: School Smart Mathematics Students, Mathematics Perspective for the Real World, and Creative Problem Solvers. We performed separate step-wise regressions for each of these factors.

Data analyses indicated that years of experience teaching mathematics, highest level of teaching mathematics, and highest degree earned were significant predictors for the School Smart Mathematics Students factor. Teachers who taught higher grade levels were less likely to value School Smart Mathematics Students. Teachers who taught mathematics for more years were more likely to value School Smart Mathematics Students. Teachers who had higher degrees were less likely to value School Smart Mathematics

Table 5: Step-wise regression analysis summary for teacher characteristics variables predicting school smart mathematics students (*N*=947).

Variable	*B*	SE*B*	β	R^2	ΔR^2
Step 1				.046	
Highest Grade Level Teaching Math	-.054	.008	-.214		
Step 2				.091	.045
Highest Grade Level Teaching Math	-.068	.008	-.273		
Number of Years Teaching Math	.004	.001	.219		
Step 3				.096	.005
Highest Grade Level Teaching Math	-.061	.009	-.243		
Number of Years Teaching Math	.004	.001	.228		
Highest Degree Earned	-.028	.012	-.081		

Note: Gender was not a significant predictor.

Table 6: Step-wise regression analysis summary for teacher characteristics variables predicting gifted students mathematics perspective for the real world (*N*=947).

Variable	*B*	SE*B*	β	R^2	ΔR^2
Step 1				.021	
	Highest Grade Level Teaching Math	-.027	.006	-.146	
Step 2				.041	.020
	Highest Grade Level Teaching Math		-.035	.006	-.185
	Number of Years Teaching Math	.002	.000	.146	
Step 3				.060	.019
	Highest Grade Level Teaching Math	-.033	.006	-.177	
	Number of Years Teaching Math	.002	.000	.186	
Gender		-.035	.009	-.142	

Note: Highest degree earned is not included.

Table 7: Step-wise regression analysis summary for teacher characteristics variables predicting creative problem solvers (N=947).

Variable	B	SEB	β	R^2	ΔR^2
Step 1				.035	
	Highest Grade Level Teaching Math	-.036	.007	-.188	
Step 2				.050	.015
	Highest Grade Level Teaching Math	-.043	.007	-.221	
	Number of Years Teaching Math	.002	.000	.123	

Note: Highest degree earned and gender are not included.

Students. These variables accounted for 9.6% of the variance (see Table 5). This is a small, but significant, effect size. This indicates older teachers, evident by the number of years they taught, were more likely to value traditional mathematics skills such as computational speed and accuracy. Teachers with more advanced degrees and those who taught higher level courses were less likely to place a high value on these skills.

Step-wise regression analyses indicated that highest grade level teaching mathematics and numbers of years of teaching mathematics were significant predictors for the Creative Problem Solvers factor. Teachers who taught higher grade levels were less likely to value students as Creative Problem Solvers. Teachers who taught mathematics for more years were more likely to value students as Creative Problem Solvers. These variables accounted for 5% of the variance (see Table 7). This represents a small, but significant, effect size. Once again, the teachers who probably taught higher level mathematics were less appreciative of students who generated a variety of ideas and possible solutions compared with the more experienced teachers who were more likely to value computational skills. They were also more appreciative of divergent thinking students.

We used a MANOVA to determine whether there were any differences among mathematics teachers from South Korea, Turkey, and United States in terms of their ratings of mathematically gifted students' characteristics. The independent variable was the teachers' country while the dependent variables were our three factors (Mathematics Perspective for the Real World, School Smart Mathematics Student, and Creative Problem Solvers). The Wilk's lambda statistic showed a significant statistical difference in attitudes among mathematics teachers in South Korea, Turkey, and United States. Wilk's lambda was .571, F (6, 1884) =101.547, p < .001, η^2 = .244. Since there was statistical significance in the multivariate analysis, we individually examined the dependent variables (School Smart Mathematics Student, Mathematics Perspective for the Real World, and Creative Problem Solvers) and performed univariate analyses. Researchers differ on whether Discriminate Function Analysis or ANOVAs are more appropriate for post hoc analysis of significant multivariate results. We chose the latter because we were more interested in differences on the individual factors. Each of the factors was significant as shown in Table 8.

Since there were three groups in the sample and there were significant differences in the factors, a Scheffé post-hoc analysis was conducted. The Scheffé post-hoc accounts for increased Type I error due to multiple analyses. This analysis showed the means of each country differed significantly (p < .05) from each other (see Table 9 for effect sizes). Turkish mathematics teachers valued all three factors the highest among the three countries. South Korean teachers were the

Table 8: Univariate analysis of dependent variables for countries.

Source	Dependent Variable	SS	df	MS	F	Sig.
COUNTRY	School Smart Mathematics Students	7.762	2	3.881	210.618	<.001
	Mathematics Perspective for the Real World	1.435	2	.718	52.639	<.001
	Creative Problem Solvers	1.531	2	.765	52.540	<.001
Error	School Smart Mathematics Students	17.396	944	.018		
	Mathematics Perspective for the Real World	12.869	944	.014		
	Creative Problem Solvers	13.754	944	.015		

least likely to value the School Smart Mathematics Students and Mathematics Perspective for the Real World factors. United States teachers valued the Creative Problem Solvers factor the lowest. See Table 10 for means and standard deviations prior to and after data transformation. The data analysis used the transformed scores; however, the non-transformed scores are easier to interpret since they represent the measurement metric used with the survey.

Finally, we were interested in whether the mathematics teachers from these three countries differed in their view of mathematics and the way they thought mathematics should be taught. We conducted one-way ANOVAs with Scheffé post-hoc follow up. In each of the nine variables we measured, there was at least one significant difference among South Korean, Turkish, and United States teachers. A graphic representation of these results is shown in Figure 1. ANOVA results and group means and standard deviations are shown in Table 11.

Table 9: Effect Size Differences Using Cohen's *d*.

Country	Turkey	USA
Factor 1: School Smart Mathematics Students		
South Korea	1.585	1.036
Turkey	--	0.522
Factor 2: Mathematics Perspective for the Real World		
South Korea	0.773	0.545
Turkey	--	0.265
Factor 3: Creative Problem Solver		
South Korea	0.418	0.398
Turkey	--	0.810

Note: All were significantly different from each other. Calculations were based on transformed data.

Table 10: Descriptive statistics for rating of gifted mathematics students characteristics factors by South Korean, Turkish, and U.S. teachers.

	Non Transformed			Transformed		
Country	*M*	*SD*	*n*	*M*	*SD*	*n*
Factor 1: School Smart Mathematics Students						
South Korea	3.221	.819	296	.276	.137	296
Turkey	4.298	.570	389	.490	.132	389
USA	3.993	.626	262	.419	.139	262
Total	3.877	.814	947	.403	.163	947
Factor 2: Mathematics Perspective for the Real World						
South Korea	3.695	.573	296	.351	.113	296
Turkey	4.117	.579	389	.443	.124	389
USA	3.998	.507	262	.412	.110	262
Total	3.952	.586	947	.406	.123	947
Factor 3: Creative Problem Solver						
South Korea	4.215	.500	296	.465	.119	296
Turkey	4.401	.534	389	.516	.125	389
USA	4.016	.523	262	.418	.116	262
Total	4.236	.543	947	.473	.127	947

Table 11: ANOVA results and means and standard deviations for teachers attitudes about how to teach mathematics.

	S. Korea		Turkey		USA	
	M	*SD*	*M*	*SD*	*M*	*SD*
Mathematics is primarily an abstract subject. F (2, 934) = 24.810, $p < .001$, $\eta^2 = .050$	2.818	.684	2.824	.864	2.425	.717
Mathematics is primarily a formal way of representing the real world. F (2, 931) = 10.467, $p < .001$, $\eta^2 = .022$	3.105	.553	3.222	.662	3.000	.583
Mathematics is primarily a practical and structured guide for addressing real situations. F (2, 931) = 39.178, $p < .001$, $\eta^2 = .078$	2.922	.588	3.341	.644	3.096	.612
If students are having difficulty, an effective approach is to give them more practice by themselves during the class. F (2, 929) = 148.557, $p < .001$, $\eta^2 = .242$	3.122	.639	2.858	.891	2.031	.725
Some students have a natural talent for mathematics and others do not. F (2, 937) = 23.367, $p < .001$, $\eta^2 = .048$	3.003	.721	3.372	.722	3.222	.629
More than one representation (picture, concrete material, symbol set, etc.) should be used in teaching a mathematics topic. F (2, 939) = 77.161, $p < .001$, $\eta^2 = .141$	2.922	.614	3.368	.680	3.554	.550
Mathematics should be learned as sets of algorithms or rules that cover all possibilities. F (2, 930) = 115.643, $p < .001$, $\eta^2 = .199$	2.810	.669	3.053	.752	2.167	.760
Basic computational skills on the part of the teacher are sufficient for teaching mathematics. F (2, 938) = 97.438, $p < .001$, $\eta^2 = .172$	1.686	.648	2.329	.927	1.485	.806
A liking for and understanding of students are essential for teaching mathematics. F (2, 939) = 55.375, $p < .001$, $\eta^2 = .106$	3.108	.695	3.594	.627	3.580	.631

Note: The means of each country differed significantly ($p < .05$) from each other.

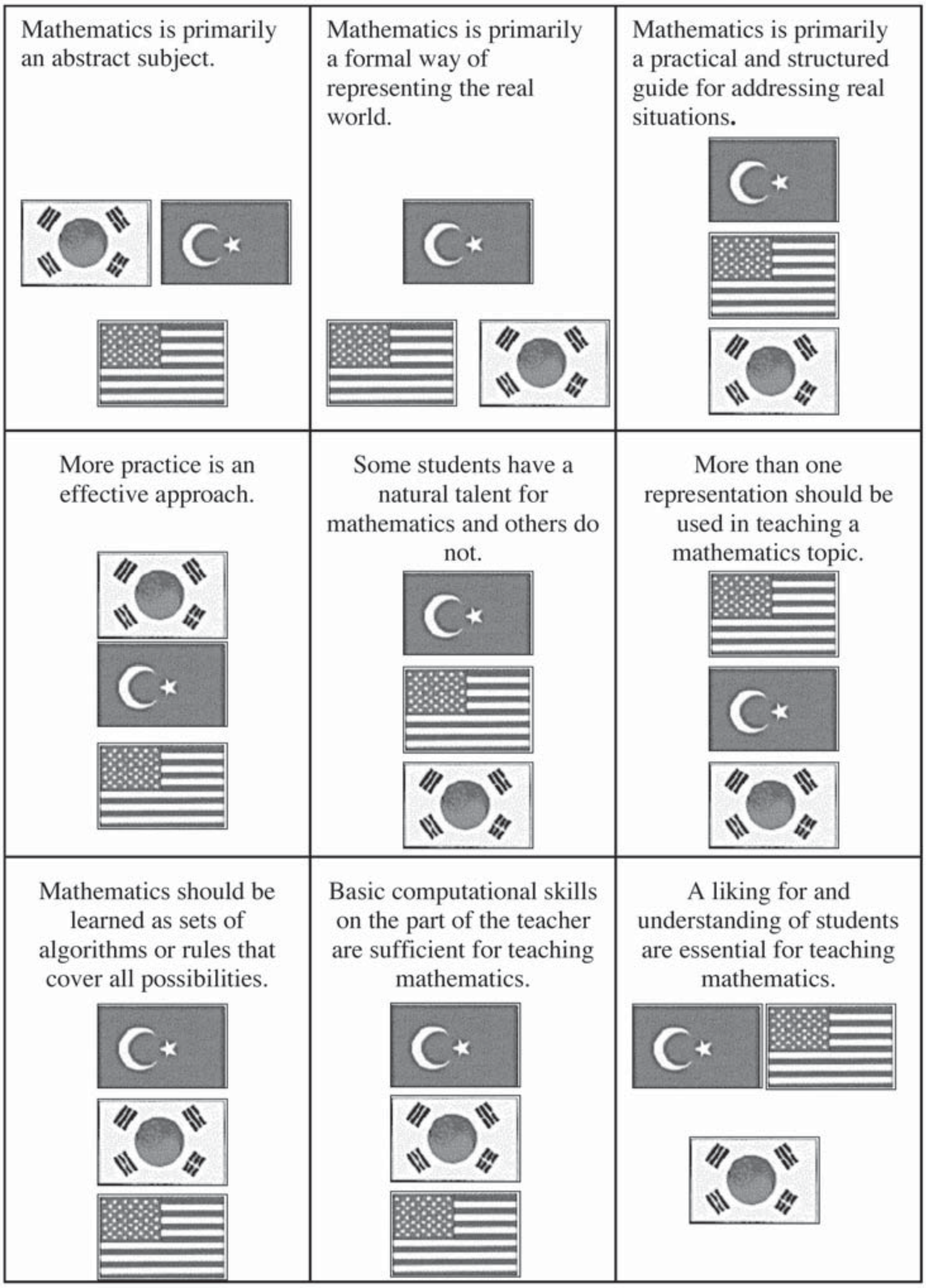

Figure 1: Differences in teachers' views about mathematics and the teaching of mathematics are represented by vertical differences in country flags.

Discussion

Characteristics of Talented Mathematicians

The more years teachers taught mathematics, the more likely they were to report students' arithmetic skills, their ability to relate mathematics to everyday life, and their ability to generate multiple and unique solutions to problems as indicators of mathematical talent. Experienced teachers may be better able to identify gifted students with these characteristics and possibly see connections between mathematics and its applications.

The opposite was true for highest level of mathematics taught. The higher the grade level of mathematics taught, the less teachers valued each of these factors. This was unexpected. We expected teachers who taught more advanced courses (which would appear in higher grade levels) would be less impressed with students' arithmetic skills, but not less impressed with students ability to relate mathematics to everyday life or ability to generate a variety of possible solutions to problems. One possible explanation is the restriction of range with our Turkish and

South Korean sample. Turkish teachers mostly taught grades 9-11 (most high schools in Turkey only serve students through grade 11), and South Korean teachers mostly taught grades 10-12. Because the ANOVA results showed Turkish teachers most positive about the three factors and South Korean teachers least positive, their limited grade teaching range may have influenced the regression results. We had hoped to analyze the country variable with the demographic variables but limited cell sizes precluded this option.

It may be that the higher the grade level, the higher the stress level for university entrance exams. Teachers and students may worry about covering the necessary curriculum to prepare students for college entrance exams. This may be more of a concern in South Korea and Turkey. This high stress environment at higher grade levels may leave little room for teachers to appreciate Mathematics Perspective for the Real World and Creative Problem Solvers. A stressful atmosphere may not, therefore, create a friendly environment for gifted students to show their talents at higher grade levels. This is a possible area of future research considering the rising popularity of high-stake testing within the United States.

We were not surprised teachers with advanced degree were less impressed with arithmetic skills. While not found, we thought a relationship might exist between level of degree earned and appreciation of students' ability to relate mathematics to everyday life and students' ability to generate multiple and unique solutions to problems.

As previously stated, Turkish teachers expressed stronger acceptance of each of the factors. This may be because the Turkish Ministry of Education conducted the survey which could have caused the teachers to be more accepting. U.S. teachers tended to be followed by South Korean, except for the multiple solutions to problems factor, which South Korean teachers rated higher than U.S. teachers. As expected, the teachers overall in each country rated each of the factors high (M=3.221 to 4.401 on a 5-point scale). Creative problem solving received the greatest support, and the traditional school-smart arithmetic skills received the least support.

Ways Mathematics Was Viewed and Should be Taught

South Korean teachers, whose country's students score near the top on international mathematics exams, are less likely to view mathematical talent as innate. They view mathematics as an abstract subject in which students experiencing difficulties should be given time in class to practice by themselves. They are less likely to see mathematics as a practical topic or a formal way of representing the world. They are less likely to use a variety of representations (pictures, concrete objects, and symbols) when teaching mathematics.

Turkish teachers, whose students score low on international tests, also see mathematics as an abstract subject. However, they are more likely to believe some students have a natural mathematical talent. They see mathematics as relating to the real world. They also are more likely to believe it should be taught as a series of algorithms and that the possession of basic computational skills by the teacher is sufficient to teach mathematics.

United States' teachers, whose students score somewhere between South Korean and Turkish students on international tests, are least likely to see mathematics as abstract. They are also least likely to support individual practice during class time and less likely to place an emphasis on teaching algorithms. They also are more likely to disagree that possession of basic mathematics skills is sufficient to teach mathematics.

Limitations of the Study

Several limitations exist in this study, including survey return rates, reliance on self-reporting, and voluntary participation. Although the U.S. survey return rate was low (26%), the questions on our survey imported from TIMSS received similar responses to those administered by TIMSS, perhaps indicating the study data collected in the U.S. is probably representative of U.S. teachers. Responses for Turkey were also moderately related to TIMSS. The relationship with the South Korean data was also somewhat related, although less than the data from the U.S. and Turkey. Based on this, survey data appear to be representative of the opinions of teachers in the countries surveyed.

The nature of the self-reporting data is a concern in Turkey because the Ministry of National Education collected the data. Teachers in Turkey may have wished to please their supervisors who conducted the survey, although we have no reason to believe this was the case.

The surveys were effectively translated from English to Turkish and Korean and retranslated to English. Reliability coefficients for the three factors in each language were similar.

Conclusions

Identifying and providing services to gifted mathematicians is of paramount importance in a rapidly shrinking global economy that requires advanced technological skills. We found the most valued characteristic for young mathematicians to possess is creativity in approaching problem solving. Gifted education has been in the forefront of developing student creativity skills. Educators of the gifted should continue this practice while expanding it to encompass academic content. In other words, mathematics instructors should help promising mathematicians develop their creativity and apply it to solving mathematics problems. This research demonstrated that more experienced teachers were more likely to value this trait in young gifted mathematicians. On the other hand, those who taught higher grade levels of mathematics did not. If diverse thinking is, in fact, a valuable skill for gifted mathematicians to possess, then instructors of higher-level mathematics should appreciate and consider incorporating this type of thinking into the courses they teach.

Traditionally, Asian culture places a high value on effort over ability. The South Korean teachers' responses support this. These teachers, whose country's TIMSS scores are the highest of the three countries we studied, appear to support more traditional approaches to teaching mathematics and believe that students' mathematical skills are developmental. The current trend in the United States is toward less traditional approaches to teaching mathematics (NCTM, 2000). Teachers in the U.S. are also more likely to see mathematic talent as innate. These are areas in the United States that require additional research and dialog.

Note: This research was supported under the Educational Research and Development Directorate (ERDD), Republic of Turkey National Ministry of Education. We also wish to thank Dr. Hong-Won Kim and Dr. Yurdanur Atlioglu for their assistance with survey distribution and collection.

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