Exploring the Middle School Mathematics Teacher Student Relationship

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Abstract – Engineering, grounded in mathematics, mandates that students understand mathematics and have highly developed mathematics skills. Unfortunately, studies reveal that U.S. students' perform at moderate levels. We believe the teacher student relationship holds the key to student performance. It seems that students do not enter school with negative attitudes, so perhaps they originate from teachers. Middle school students must participate in a college bound algebra course by eighth grade to be situated for college preparatory mathematics courses in high school. Unfortunately, many students are often missing from rigorous mathematics classrooms due to past performance. We believe improving the teacher student relationship may interrupt the lackluster performance cycle making engineering more available to students as a future career. To answer our research question, multiple linear regression and path analysis were used on data from the 2007 Trends in International Mathematics and Science Study linking teacher and student attitudes with student mathematics scores.

Key Words: care-theory, linear regression, mathematics, middle school teachers

INTRODUCTION

Mathematics and science education are the root of engineering principles and practices. Research shows that success in mathematics is a key reason for students choosing to study engineering [4, 28, 31], which suggests that success in mathematics should lead additional students to study engineering. It has also been shown that mathematics and engineering are often complimentary when engineering applications are used to explain mathematics concepts [10]. Educational stakeholders continue to search for answers in an effort to address the lackluster mathematics performance of many students which may lead them away from engineering. Educational researchers address the problem from many perspectives, focusing on social institutional structures and beliefs that impact students' success in mathematics [7, 15, 17], mathematics curriculum [9, 13, 14, 30], teaching pedagogy [3, 8], teacher content knowledge, and teacher mathematics achievement [6, 16, 29]. Current research exploring the teacher student relationship suggests the relationship does impact student academic performance. Hackenburg [5] cites research addressing student achievement and student engagement based on the teacher student relationship [2, 24, 27], and she [5] cites several studies exploring motivation as it relates to the teacher student relationship and its impact on student academic performance [18, 21, 26, 32]. The focus of this paper is the teacher student relationship framed in care theory and mathematics anxiety, which may affect both the teacher and the student.

FRAMEWORKS

Care theory addresses both attention and action which focuses on both the person who provides the care (the carer) and the person who receives the care (the cared-for) where in the classroom, the teacher is the carer and the students are the cared-for [22, 23]. Goldstein [11] contends that "caring is not something you are but, rather, something you engage in, something you do" (p. 656). This notion of care as a behavior demonstrates that care impacts the activities in the classroom which extends beyond simply the atmosphere in the classroom or the reflection of the teachers' attitudes. Care theory does not refer to empathy or passion for your students; that would be natural caring [11]. When care theory is the basis for actions in the classroom, there are two types of caring that emerges at the forefront: (1) relational caring and (2) virtue caring [23]. Relational caring is based upon the connection between

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two people opposed to virtue caring that is seen more as the good act of one person in the relationship [23]. Noddings [23] states that in some cases "no matter how hard teachers try to care, if the caring is not received by the students, the claim 'they don't care' has some validity" (p. 15). This draws back to the notion of caring as relational where both the students' and the teachers' attitudes contribute to the relationship and as our research suggests, the success of students in mathematics.

Focusing on the teacher student relationship, mathematics anxiety may be a shared issue held by both teacher and student. Research shows that negative experiences in mathematics courses may have long lasting effects on students [12]. Many researchers perceive mathematics anxiety as a deficit model, where a cognitive or psychological deficit resides within the individual, while others perceives the anxiety within the classroom, where the dynamics between curriculum, interpersonal skills, such as between the teacher and student, and teaching methods, are the contributing factors. Mistele and Spielman's [19] research among predominately elementary and middle school mathematics pre-service teachers suggests that mathematics anxiety is situated within the classroom and as such, should not be perceived as a deficit model but a situated model. This supports Williams [33], who showed that people are generally not mathematics anxious prior to attending school. The research focusing on pre-service teachers and students suggests that mathematics anxiety may impact the teacher student relationship within the classroom. Drawing on our previous connection of mathematics and engineering, improving this relationship may increase the number of students who choose engineering as a profession.

Therefore, we explore the teacher student relationship framed by care theory to examine teacher attitudes as perceived by their students to understand the impact the relationship may have on student mathematics achievement. Our research question differs from past studies in terms of data sources and methods of analysis, where the majority of current research uses qualitative methods based on case studies or a small select population [5]. This study uses quantitative methods and a large national data set to answer our overarching question, *how does teacher attitude mediate eighth grade students' attitudes toward mathematics, which impacts their mathematics achievement scores and ultimately their choice to pursue engineering?* We conjecture that a crucial component for middle school students experiencing success and confidence, while engaged in rigorous mathematics classes, begins with the relationship between the teacher and the student.

METHODS

This is a cross sectional non experiment study using the U.S. TIMMS 2007 public data resources, where we focused on examining data related to eighth grade mathematics students, which includes a student survey instrument, a teacher survey instrument, and students' mathematics achievement scores. The data we used is publically available at http://nces.ed.gov/timss/results07.asp. The notion that student attitudes and teacher attitudes cannot be randomly assigned is valid; they are manipulable. In addition, the notion that socio-economic status (SES) may affect both attitude and achievement scores among students was a concern; therefore, it was controlled in an effort to more accurately estimate the effects of the relationships in the study. The three data sets, the student and teacher surveys along with the achievement scores, were used in an effort to explain the relationship between teachers' and students' attitude concerning mathematics and the relationship between teacher and student as they may impact student's mathematics achievement scores. The basis for analysis uses the student data where the teacher data is matched to the student through unique identification codes.

Approximately 5% of the student data is double counted because a few of the students are linked to two different mathematics teachers because they are likely enrolled in two mathematics courses. Due to this being a small percentage of the student sample, the sample data remained intact. It should be noted that all analyses performed on the data used the relative weight of each item based on the students' total weight within the sample.

Participants

As stated in the TIMMS 2007 Technical Report [25], the U.S. sample of TIMSS 2007 includes both public and private schools, randomly selected and weighted to be representative of the nation. In total, 239 eighth grade schools, 532 eighth grade mathematics teachers, and 7,377 eighth grade students participated in the study, and weighting was used to adjust for the complex sample design in order to obtain accurate population estimates [25]. The U.S. sample followed a two-stage sampling process with the first stage being a sample of schools and the second stage a sample of classrooms within schools where all students in the sampled classrooms were selected for assessment and by default, the teachers were selected for the study in order to connect student assessment scores to the classroom teacher [25].

Sampling Procedures

According to the technical report [25], the first stage of the sampling design considers the schools and focuses on the profile of the proportion of public and private schools in the country and the proportion of the schools within four regions: South, West, North Central, and the Northeast. The second stage is the classroom where the size is set to a minimum of 20 students; if the number of students in a classroom is less than 20 students, then a pseudo-classroom is constructed by joining the small classroom to another classroom [25]. In addition, the student profile within the classroom is also considered.

The TIMSS organization implemented a nonresponse bias analysis on the U.S. data because the U.S. response rate was less than 85% at the school level [25]. The technical report [25] cites other bias studies to inform their own bias analysis for this data set, which they indicate is similar to other NCES nonresponse bias studies. In conclusion, the investigation into nonresponse bias at the school level for U.S. TIMSS 2007 samples for grades 4 and 8 showed that there was no statistically significant bias due to the low response rate [25].

The school level sampling frame was the 2003 – 2004 Common Core of Data (CCD) for the public schools and the 2003 – 2004 Private School Survey (PPS) for the private schools [25]. The goal for the TIMSS sample was to attain a self-weighting student sample, and to achieve this, schools' probability of selection was related to their measure of size (MOS), which is proportional to its share of the target population [25]. The TIMSS organization indicates that this method also reduces the chance to select smaller schools, which reduces the very large weights these smaller schools would otherwise have [25]. The schools were selected in proportion according to their private and public status as well as their region in the country, and to randomly select the schools from the sampling frame, within each stratum, a sampling interval was calculated by dividing the total measure of size by the sample size [25].

The second stage addressed the selection of the classrooms within schools. Within each sampled school, all of the mathematics classrooms were listed on the classroom sampling frame, and classrooms with fewer than 15 students were collapsed into pseudo-classrooms, so that each classroom on the school's classroom sampling frame had at least 20 students [25]. An equal probability sample of two classrooms or pseudo-classrooms was sampled from the classroom frame for each school, and all of the students within a selected classroom where included in the study [25]. This allows for the matching of the students with their classroom teacher for teacher student relationship research like the research performed in this study.

Assessment data for TIMSS 2007 were collected through pencil-and-paper assessments administered to the students and through surveys completed by principals, teachers, and students in the U.S [25]. The assessment items included multiple-choice and constructed-response items, which were scored according to a rubric, and the total scores for mathematics and the scores that reflect performance in specific domains of mathematics were estimated using an item response theory (IRT) model [25]. This means, the eighth grade assessment had four scales that described the four content areas for mathematics: number, algebra, geometry, and data and chance, in addition, to the three cognitive domains in mathematics [25].

To accommodate the missing data, plausible values were estimated based on the students who were participating in the assessment [25]. The plausible values are estimated from five random draws from an empirically derived distribution of score values based on the student's observed responses to assessment items and on background variables [25]. Achievement results from TIMSS are reported on a scale from zero to 1,000, with a TIMSS scale average of 500 and standard deviation of 100 [25].

In total, each TIMSS cycle gathers data relating to four separate surveys/assessments which are developed by all countries participating in the study [25]. The first is a student achievement assessment in mathematics and science, the second is a student survey, the third is a teacher survey, and the fourth is a general school survey [25]. Each of these items is administered by trained personnel, and the results are recorded nationally for future analysis [25]. Each item asks a variety of questions relating to mathematics and science in the elementary classroom. For the purposes of our research, we focused on questions relating to student and teacher attitude towards mathematics along with the students' mathematics achievement scores.

Research Design

The teacher student relationship is complex, where the student attitude and the perceived teacher attitude are multifaceted. In an attempt to explore the teacher student relationship, a teacher attitude construct and a student attitude construct were developed using the teacher survey data and the student survey data. The teacher attitude construct focused on the attitudes held by the teachers concerning teaching mathematics, the teaching environment, and their attitudes towards their students. The student attitude construct addressed student's attitudes towards school, learning mathematics, and their perceptions of their teacher's attitude toward their learning. Both of these constructs along with the students' mathematics achievement scores served as the basis for the analysis. In addition, these two attitude constructs were further developed to generate scores that were divided into three categories: (1) low attitudes, (2) medium attitudes, and (3) high attitudes, where the teacher and student identification numbers were used to map the student's attitudes to their own teachers' attitudes. The research design consists of four parts:

1.) Explores the teachers' attitudes toward their level of preparedness to teach mathematics.
2.) Explores the relationship between teacher attitudes and student mathematics achievement scores and the relationship between student attitudes and their mathematics achievement scores.
3.) Examines the effect of the mediating factor, teacher attitude, on student achievement scores.
4.) Examines the general relationship between teacher attitudes and student attitudes in the sample.

The remainder of the research design section provides details addressing the design and evaluation of appropriate constructs and variables used to explore the research questions.

The first part in the analysis determines the level of preparedness the teachers held to teach eighth grade mathematics, where their level of preparedness for specific mathematics content strands, numbers and operation, probability and data analysis, geometry, algebra, were explored. Initially, we specifically explored teachers' response to teaching algebra, which is addressed in question seven of the teacher survey. The exact question can be found in Appendix A.

The second part of the analysis involved performing linear regression as a means to implement the path analysis model using two constructs: teacher attitude and student attitude. The teacher attitudes construct was created using questions 10, 12 (a, d, g, h), and 19 (a, b, c, d, e) from the teacher survey; see Appendix A for the questions. The response items in the teacher survey were all in the same direction. Questions 10 and 19 use a four point Likert scale, after the items in question 19 were recoded so the first category labeled "Not Applicable" was treated as missing and the subsequent categories had their score values reduced by one. The items in question 12 use a five point Likert scale, where they were restructured to align to a four point scale after each frequency histograms was evaluated. That is, responses in item 19a showed 2.2% belonged to category 5 therefore it was collapsed with category 4 responses. Likewise, the same was true for item 19d, where 0.3% of the responses belonged to category 5. Item 19g showed 2% of the responses belonged to category 1, and therefore, category 1 was collapsed with category 2, which required the reduction in number value by one for the other response categories so that the remaining categories become a 4 point scale. Likewise, the same collapsing and renumbering was performed on item 19h where 4.2% of the responses were assigned to category 1 and collapsed with category 2. The remaining categories were renumbered.

A reliability analysis using Cronbach's Alpha shows, when applied to the modified question items, $\alpha = 0.819$. This means they are appropriate to create a construct to represents teacher attitudes. The averages for each question was calculated, (New_ave10, New_aveQ12, and New_ave19), where the descriptive statistics show they lack a normal distribution, and all were positively skewed; New_ave10 was leptokurtic, while New_aveQ12 and New_ave19 were platykurtic. The averages of these questions were again averaged together to create the final teacher attitudes variable, where the assumption for a normal distribution was checked. The construct showed skewedness and kurtosis, but when transformed using a log function, the skewedness was eliminated and the kurtosis was reduced indicating the distribution remains platykurtic (-.34, -6.29).

The student attitude construct uses all of the items in questions 9, 10, and 16 from the student survey; see Appendix A for the questions. Question 9 items c, e, and g were reversed coded for scale agreement with the other survey items. All the questions use a Likert four point scale.

A reliability analysis using Cronbach's Alpha shows that all of the items in the construct are suitable to represent student attitude, $\alpha = 0.851$. The average for each question was calculated, AveQ9s, AveQ10s, and AveQ16s, where the descriptive statistics show each question lacked a normal distribution, and all were positively skewed. AveQ10s and AveQ16s showed platykurtic, and AveQ9s showed leptokurtic. The averages of the student questions were again averaged together to create the final student attitudes variable, where the assumption for a normal distribution was checked. The construct showed skewedness and kurtosis, but when transformed using a log function the skewedness was eliminated and the kurtosis was reduced indicating the distribution remains platykurtic (-1.5, -6.29).

In addition to the attitude constructs, the student standardized mathematics scores were used in the regression analysis. It should be noted that the mathematics scores alone violate both skewness and kurtosis. A log transformation was performed on the data to eliminate or reduce the violation, but the values remained relatively unchanged. Since the log transformation did not correct the data to achieve normality, it was returned to its' original form for use in the analysis.

After developing the above variables, three assumptions were addressed during the process. The three assumptions are: (1) *Normal Distribution*, where a lack of normality for the teacher attitude construct and the student attitude construct was addressed through log transformations, which did not eliminate it but did reduce the lack of normalcy through reducing the skewness. (2) *Homogenous Variance or Errors* is based on the sampling method employed by the TIMSS organization. We suspect our variances to be under-estimated, however, none of the variances among the three teacher average variables have variances that are approximately identical; none are greater than four times the other, which suggests homogenous variance in errors, and likewise, among the student attitudes average variable. (3) *Independence* of responses was met.

An extensive effort was applied to creating an appropriate SES construct since a constructed variable was not included in the data set. The attempts included various combinations for items such as mother and father highest education level achieved separately, mother and father highest level of education achieved as one item, race, and selecting items found in the home, such as a computer, and internet service. However, the identification of the items owned in the home was dichotomous data, and the parental educational achievement was student reported showing that 28% of the students lacked knowledge of their parents' highest level of educational achievement. The numerous attempts to create a suitable SES construct resulted in Cronbach's Alpha values severely below the 0.80 desirable levels. Therefore, we use the student reported parent's highest level of education achieved as our control variable for SES, which is less than ideal.

A third part of the research using path analysis was performed to determine if teacher attitude mediates student standardized mathematics achievement scores (See Figure 1).

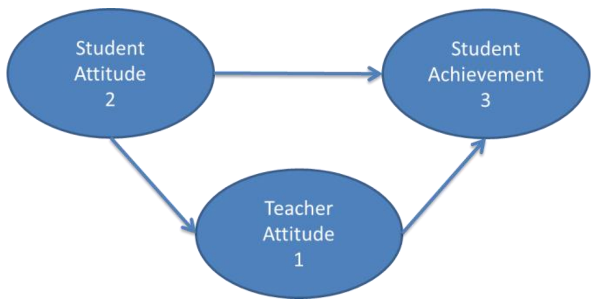

Figure 1: Path Model

This requires a closer examination of teacher attitude to determine if it is a mediating factor. If teacher attitude shows to be a mediator, then we can determine the level of mediation teacher attitude has on student standardized mathematics scores.

This final section of the research design examines the distribution of various levels of attitude between the students and their teachers. This table, Table 2, examines the relationship in both directions accounting for low, medium, and high student and teacher attitudes. The table compares the average teachers' attitude to the average students' attitude across the three ranking categories. The average teachers' attitudes are equally split into three groups, low, medium, and high attitudes and matched with their average students' attitudes also divided into three equal groups, low, medium, and high attitudes. The table created for this analysis reports the percentage of student participants that fall into each of the nine possible groups.

RESULTS

The first part of the study examines the teacher's level of preparedness to teach a specific subject in mathematics. Question seven on the teacher survey was used to determine the preparedness. Question seven can be found in Appendix A. To determine that preparedness of teachers in various subjects, simple histograms and descriptive statistics of their average responses to each of the items in the subjects were created using statistical software. Table 1 shows the means and standard deviations of the average of the questions in each subject category relating to teacher preparedness.

Table 1: Descriptive Statistics based on Mathematics Subject

	Mean	Stadard Deviation
Number	2.04	0.231
Algebra	2.06	0.256
Geometry	**2.13**	0.286
Data	2.10	0.296

The histograms of the average scores for each subject items showed that all four of the categories were highly skewed to the right. The mean scores that range between 2 and 3 indicate the teachers felt "very well prepared" to "somewhat prepared" to teach the topics. The table shows that the teachers felt least prepared to teach geometry and most prepared to teach number and operations.

Next, the analysis determining the level of teacher attitude that may mediate on student standardized mathematics scores, while controlling for SES was conducted. The assessment of teacher attitude as a mediating factor is addressed first by determining if a correlation exists between all of the variables in the model and the effect size. This begins with the correlations between student attitudes and student standardized scores, which are significantly statistically correlated ($r = 0.338$, $\log \beta = -0.192$, $p < 0.001$, $\eta^2 = 0.038$). Then, the relationship between teacher attitudes with the student standardized scores is examined to find that a statistically significant relationship exists between these two variable, ($r = 0.353$, $\log \beta = -0.219$, $p < 0.001$, $\eta^2 = .045$). Likewise, when student attitude and teacher attitude were both predictors on the dependent variable, standardized mathematics scores, the relationship remained significantly correlated ($r = 0.397$, $\log \beta = -0.185$, $p < 0.001$, $\eta^2 = 0.035$ (student) and $\eta^2 = 0.040$ (teacher)). The last relationship examined is between the student attitude and the teacher attitude, where a statistically significant relationship must exist in order for teacher attitudes to mediate student mathematics achievement scores through student attitudes. The correlation between student attitude and teacher attitude by regressing teacher attitude on student attitude, find a statistically significant correlation ($r = 0.259$, $\log \beta = 0.066$, $p < 0.001$, $\eta^2 = .004$). According to Cohen's [1], an effect size below 0.20 is small. All of our effect sizes would fall into this level, but all of the relationships are significant and given the size of the sample, we proceeded with our analysis.

To evaluate the level of mediation teacher attitude has on students' standardized mathematics scores, we see that the β in absolute value, is reduced from 0.192 to 0.185 from the first path, where student standardized mathematics scores are regressed on student attitudes to the third path, the hierarchical regression, where student standardized scores are regressed on student attitudes and teacher attitudes. Teacher attitude shows a direct effect of -0.219, an indirect effect of -0.013, and a total effect of -0.232.

Finally, Table 2 shows the general distribution, in percentages, of average students' attitudes with their corresponding average teachers' attitudes for each of the 9 possible categories.

Table 2: Student Teacher Average Attitude Distributions by Percentage

		Student Attitude		
		Low	Medium	High
Teacher Attitude	Low	**13.5**	**13.2**	11.9
	Medium	9.2	8.6	9.6
	High	9.7	**12.3**	**12**

Table 2 highlights that the highest percentages of students fall into the low and medium student attitude that maps to the low teacher attitude categories. The next highest percentages fall into the medium and high student attitude that map to the medium and high teacher attitude areas. As previously stated, the categories were created by equally splitting the average attitude response constructs.

DISCUSSION

Based on the teacher's belief, pertaining to their preparedness to teach a subject, shows that teachers felt least prepared to teach geometry, as demonstrated with the highest mean score, 2.13. The higher the mean score the more unprepared the teacher feels to teach the subject. The survey responses generally ranged between 2 and 3, which indicates the teachers felt "very well prepared" to "somewhat prepared" to teach the topics. This is different than our original hypothesis that algebra would be the area of most concern. All the standard deviations appear to be similar falling at about 0.2. The general distribution for all four of the subject areas is approximately the same; they are all skewed to the right. This is expected because most teachers feel prepared to teacher their subject matter.

The notion that the teacher student relationship is important to student mathematics achievement was explored through the lens of care theory and the comfort levels teachers and students exhibit towards mathematics. The data shows, by evaluating question seven on the teacher survey, that teachers are comfortable with the mathematics they teach and therefore, we conclude teacher mathematics anxiety is not a contributing factor to the teacher component in the teacher student relationship.

The path model appears to represent the TIMMS 2007 data appropriately and suggests there is significant relationship between student attitude, teacher attitude, and student mathematical achievement scores. The three linear regressions performed on the data relating student attitude to student scores, teacher attitude to student scores, and teacher attitude towards student attitude all provided significant correlations. From these three analyses, path analysis was performed, which suggested the teacher attitude is indeed a mediating factor between student attitude and student mathematics scores. Based on the data, a 10% increase in negative teacher attitude will result in a 0.009 decrease in student standardized scores when the data is returned to its original form. Therefore, teachers of eighth grade mathematics students should be aware of this connection, which suggests they need to be aware of the teacher student relationship.

Finally, the table which categorizes student attitude and their corresponding teacher's attitude into groups indicates that there seems to be some relation that teacher attitude and student attitude are indeed connected. The highest percentages of the data fall in the low teacher attitude with low or medium student attitude, and high teacher attitude medium with high student attitude. No direct statistical inferences can be made from this data, but Table 2 shows that there does seem to be a trend which is in line with the results of the path analysis.

Limitations

The limitations to our research include time, where we were unable to test alternative explanations for our research question. The time constraint prevented us from critically scrutinizing our model, which includes adjusting our model equations to consider confounding or other sources of bias. In addition, we were unable to explore in depth the notions of virtue-caring and relational-caring as they may have been used in other studies. This knowledge may have informed our decision to fold the two types of caring into a consolidated teacher attitude construct, which we suspect may have introduced confounding and bias. However, these limitations shed light on our next steps in our research exploring the relationships between teacher attitudes, student attitudes, and student mathematics achievement scores.

Future Research

This research opens the door for further investigation into the exact effects of teacher attitude on students including a possible analysis where attitudes and scores are separated into racial-ethnic groups or by gender. This may inform the mathematics education community of the need for teachers to be cognizant of the type of teacher student relationship that is of value to each student. This knowledge may impact the teacher student relationship allowing former marginalized students who have often been missing from the more rigorous mathematics classrooms [20] to take their seats in these classes. We contend this deeper investigation offers greater potential to impact teacher student relationships, which results in students experiencing greater success in mathematics.

This study may set the stage for longitudinal research, where students are followed from the middle school years to high school graduation when career choices, such as engineering, are made to better understand how teacher student relationships affected their choices. Likewise, the longitudinal studies may evaluate the impact that negative mathematics experiences and perceived unsatisfying teacher student relationships may have in turning students away from mathematics-based professions such as engineering. We contend these future investigations may offer valuable information to the education community that may impact mathematics teacher preparation programs in k-12 education.

CONCLUSION

Based on multiple linear regression techniques and path analysis, there exists an influence of teacher attitude on student attitude and ultimately student achievement scores in mathematics. This observation, framed in care-theory, suggests that if improvements to teacher attitudes are made, student attitude will increase, therefore improving student achievement in mathematics. We believe that such an increase in mathematics achievement may lead students to pursue careers in mathematics based fields, mainly engineering. Future research into how this could be accomplished and the direct ramifications in terms of career choice is needed.

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Appendix A

Teacher and Student Survey Questions Used in This Research Only
(These questions are directly from the TIMMS 2007 surveys)

Teacher Survey Questions

7: "How well prepared do you feel you are to teach the following topic?" (1 = "not applicable," 2 = "Very well prepared," 3= "Somewhat prepared," 4 = "Not well prepared")

A. Number
   a. Computing, estimating or approximating with whole numbers
   b. Representing decimals and fractions using words, numbers, or models (including number lines)
   c. Computing with fractions and decimals
   d. Representing, comparing, ordering, and computing with integers
   e. Problem solving involving percents and proportions.
B. Algebra
   a. Numeric, algebraic, and geometric patterns or sequences (extension, missing terms, generalization of patterns)
   b. Simplifying and evaluating the algebraic expressions
   c. Simple linear equations and inequalities, and simultaneous (two variables) equations
   d. Equivalent representations of functions as ordered pairs, tables, graphs, words, or equations
C. Geometry
   a. Geometric properties of angles and geometric shapes (triangles, quadrilaterals, and other common polygons)
   b. Congruent figures and similar triangles
   c. Relationship between three-dimensional shapes and their two-dimensional representation
   d. Using appropriate measurement formulas for perimeters, circumferences, areas of circles, surface areas and volumes
   e. Cartesian plane – ordered pairs, equations, intercepts, intersections, and gradient
   f. Translation, reflection, and rotation
D. Data and Chance
   a. Reading and displaying data using tables, pictographs, bar graphs, pie charts and line graphs
   b. Interpreting data sets (e.g. draw conclusions, make predictions, and estimate values between and beyond given data points)
   c. Judging, predicting, and determining the chances of possible outcomes

10: "Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements about your school." (1 = "Agree a lot" to 4 = "Disagree a lot")

   a. This school is located in a safe neighborhood.
   b. I feel safe at this school.
   c. This school's security policies and practices are sufficient.

12: "How would you characterize each of the following within your school?" (1 = "Very high" to 5 = "Very low")

   a. Teacher job satisfaction
   d. Teachers' expectation for student achievement
   g. Student's regard for school property
   h. Students' desire to do well in school

19: "In your view, to what extent do the following limit how you teach the TIMSS class? (Students)" (1 = "Not applicable," 2 = "Not at all" to 4 = "A lot")

   a. Students with different academic abilities
   b. Students who come from a wide range of backgrounds (e.g., economic, language)
   c. Students with special needs
   d. Uninterested students
   e. Disruptive students

Student Survey Questions

9: "How much do you agree with these statements about learning mathematics?" (1 = "Agree a lot" to 4 = "Disagree a lot")

   a. I usually do well in mathematics.
   b. I would like to take more mathematics in school.
   c. Mathematics is more difficult for me than for many of my classmates.
   d. I enjoy learning mathematics.
   e. Mathematics is not one of my strengths.
   f. I learn things quickly in mathematics.
   g. Mathematics is boring.
   h. I like mathematics.

10: "How much do you agree with these statements about mathematics?" (1 = "Agree a lot" to 4 = "Disagree a lot")

   a. I think learning mathematics will help me in my daily life.
   b. I need mathematics to learn other school subjects.
   c. I need to do well in mathematics to get into the university or college of my choice.
   d. I need to do well in mathematics to get the job I want.

16: "How much do you agree with these statements about your school?" (1 = "Agree a lot" to 4 = "Disagree a lot")

   a. I like being in school.
   b. I think that most students in my school try to do their best.
   c. I think that most teachers in my school want students to do their best.