The Relation Between Interest-based Teaching Practices and Student Performance in The High School Mathematics Classroom

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By

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Abstract

This study consists of a survey that was administered online to students at the State University of New York (SUNY) Brockport in the Fall 2020 semester. Participants were recruited from a variety of academic disciplines in reference to their high school mathematics experiences. The survey was broken up into two sections. The first section asked about the mathematics class that they received the highest grade in, and the second section asked about the mathematics class they received the lowest grade in. By asking the same questions across these two sections we were able to compare which teaching practices mathematics teachers employed that had a higher impact on student performance. It was found that interest-based teaching practices in the categories of Classroom Discussions, The Learning Environment, Connections to Everyday Life, and Presentation of Topics had statistically significant differences in the mean responses of participants. The implementation of these interest-based teaching practices may lead to an increase in student performance.

Introduction

High school mathematics teachers seek instructional practices that can positively impact student learning. A few studies have investigated student interest in mathematics with hope that it will lead to an increase in student performance (Mitchell, 1993; Kosiol, Rach, & Ufer, 2019). In this study, student interest is defined as an internal sense of importance and personal meaning in an event, idea, or subject matter. When students are interested in the subject they are to learn, their attention, strategy use, and goal setting positively impact their persistence to complete challenging tasks (Renninger, Nieswandt, & Hidi, 2015). This leads one to believe that high levels of interest thus translate to increased performance. Motivation, in this case, is an inner desire to learn the subject which could possibly lead to becoming more academically successful in mathematics specifically (Anwar, Choirudin, Ningsih, Dewi, & Maseleno, 2019). Notice the difference between this definition of motivation and our definition of interest. Motivation is supported by a willingness to learn the subject matter, whereas interest is a deeper and more personal relationship between the subject as a whole and the student. Therefore, although high interest has been linked to high motivation, there is not yet a clear correlation between levels of interest and student performance.

Although this may seem like a logical conclusion, few studies have investigated the relationship between student interest and performance. Likewise, few studies have investigated teacher instructional practices and how they compared to various aspects of learning mathematics for high and low performance across typical high school mathematics courses. This study investigates the idea of interest-based teaching practices being linked to high student performance. In light of the international health crisis of 2020, it should be stated that this survey was administered to college students regarding their high school mathematics instructional experiences before hybrid and remote learning occurred with the COVID-19 pandemic.

Literature Review

There are two types of interest that have been identified by the available literature: situational and personal interest. Situational interest depends heavily on the learning environment around the student. Such interest can be promoted through conditions, objects, and experiences in the immediate vicinity of the student. For this research, the immediate vicinity is considered to be the learning environment in the mathematics classroom. Personal interest is more beneficial in promoting long-term interest in a specific topic or activity. Students with personal interest in a subject tend to be more focused, put in more effort, and find more enjoyment in the subject material than those without (Azmidar, Darhim, & Dahlan, 2017). Personal interest, however, is intrinsic. making it more difficult for teachers to effect within students. In an attempt to increase student personal interest, mathematics teachers have implemented teaching practices designed to increase situational interest which will hopefully transition into personal interest. There are five sub-facets of situational interest: meaningfulness, involvement, puzzles, computers, and group work (Mitchell, 1993).

Classroom Discussions

It is not enough to just have a discussion in a mathematics classroom, those discussions must have elements that support student learning in order to make them useful. Supportive conversations help students establish group relationships, promote conceptual understanding, and provides student feedback to adjust and support their own understanding of the concepts being discussed (Wade, 2011). There is strong evidence for predicting student interest in mathematics as a subject from mathematics self-concept, leading us to believe that practices that promote mathematics self-concept may also promote student interest (Xu, 2016).

Turner, Kackar-Cam, and Trucano (2015) stated that teachers who rely on the curriculum itself to interest and engage students rather than scaffolding interaction and discussion into their lessons were not as successful at engaging a variety of learners in their classes. Based on this conclusion, we realize that teachers must go beyond the given curriculum in order to engage students in discussions within the mathematics classroom. Classroom interactions that result in the molding and reorganizing of student thinking is one way to trigger and develop student interest in science, technology, engineering and mathematics (STEM) areas (Renninger, Nieswandt, & Hidi, 2015). Examples of such interactions are meaningful classroom discussions where students feel comfortable offering their input and where teachers offer valuable feedback to their learners.

The Learning Environment

It has been suggested that the ideal classroom environment for students consists of a strong interest and focus on the task at hand, respectful communication, support for one another, and an awareness to individual differences. Favorable student-teacher relationships have been shown to have a positive correlation with student success in terms of standardized test scores. This study, performed by Mikk, Krips, Säälik, & Kalk (2016), concludes that teacher-student relationships correlate significantly with student motivation as well as academic performance and student discipline in science and mathematics classes (Mikk, Krips, Säälik, & Kalk, 2016). Although motivation is similar to student interest, as we discussed previously, it is not the same. Using this information, it can be hypothesized that positive student-teacher relationships may also lead to an increase in student motivation.

Connections to Everyday Life

It is proposed that when students are able to use their understanding of mathematics to make sense of their own experiences and achieve purposes that are meaningful to them, they become more interested in the subject itself (Mitchell, 1993). That is, when students see mathematics as meaningful within their environment, they are more likely to become interested in the material they are learning as well as the overall subject. In this case, involvement refers to the idea that students have an active role in their learning process. The more students are involved in mathematics, the more likely the subject is to hold their interest. Although it may be tempting for teachers to create word problems about sports or video games to capitalize on the idea of relating mathematics to student interest outside the classroom, it has been observed that this approach is not beneficial to student performance. In order for students to see mathematics as meaningful to their life, there must be a deeper connection between the subject matter and its use within their everyday lives (Clinton & Walkington, 2019).

Renninger, Nieswandt, & Hidi (2015) describe specific ways to promote student interest, categorizing existing teaching practices to understand the level of situational interest a teacher is trying to incorporate into their lessons. Teaching strategies such as emphasizing connections between mathematical concepts and real-world applications, encouraging student interaction and discussion, and investigating with students the reasoning behind equations and procedures are a few strategies that have been shown to increase student interest in mathematics (Renninger, Nieswandt, & Hidi, 2015).

Presentation of Topics

Three sub-facets of situational interest, described by Mitchell (1993), are seen as short-term ways to increase meaningfulness and involvement for students. That is, computers, puzzles, and group work themselves will not necessarily lead to an increase in situational interest long-term. However, when teachers to design lessons aimed at promoting higher order thinking they may create an opportunity for more meaning and involvement for students. Therefore, these three facets can be seen as ways in which teachers implement their versions of a meaningful and involved lesson and classroom environment, which may increase situational interest (Mitchell, 1993).

Similar to the integration of Everyday Life teaching strategies, graphs, tables, and other illustrations may increase student interest, but for this instructional practice to increase student performance, the visuals must be meaningful to the topic at hand. Adding more illustrations into a lesson will not meaningfully increase student interest on their own, the visuals must create a deep connection between the illustration and the topic being discussed (Clinton & Walkington, 2019). Mayer's Coherence Principle describes the science behind this theory by stating that adding extra words, pictures, or sounds does the opposite of enhancing student learning (Mayer, 2014). In other words, illustrations can become distractions to the learning material if the teacher isn't intentional about how they are trying to increase student learning through the use of their visuals within their mathematics lessons.

Method

Data collection for this study began at the beginning of the Fall 2020 semester with recruitment and data collection taking place simultaneously. A Likert scale survey, with a scale from 1 (very rarely) to 5 (every class) was administered to students at the State University of New York (SUNY) Brockport regarding their experiences in high school mathematics classes. The participants consisted mainly of students that were taking general education psychology classes but also included students that were enrolled in an Education Certification program at the College. The survey was live for the entirety of the data collection process and participants in the study could complete the 10-20 minute survey online on their own devices at any time that was convenient for them. The participants needed to complete the survey once, and this study did not include a follow up with any participant.

Participants

There were 43 participants surveyed (female: 33; male: 8; not identified: 2) who identified ethnicity as White (32); African American (5); American Indian or Alaskan Native (1); Asian (1); and Hispanic (5). In regards to the type of high school environment the participants were from, 41 reported attending a school in the United States while only one student reported having attended high school in another country, and one did not provide a response. Of these participants, 39 reported having attended a public school. Others reported as having attended: a public charter school (1); a private religious school (1); an all-male school (1); and homeschool (1). There were also a variety of college majors represented by our participants including 24 outside of science, technology, engineering, or mathematics (STEM) majors (Women and Gender Studies, History, Sociology, Psychology, Arts for Children, Criminal Justice, Finance, Dance, Physical Education Exercise Science, Social Work, Journalism and Broadcasting, Adolescent English Education and Adolescence Education) and 16 within STEM majors (Nursing, Biology, Adolescent Mathematics Education, Earth Science Education and Chemistry) There was also 1 undeclared and 2 participants that did not identify their major.

Analysis

After the data was collected, the survey results were analyzed for both the mathematics class in which participants received the highest grade as well as the mathematics class in which participants received their lowest grade. The questions that showed to be statistically different between the mean responses fell into four categories: Classroom Discussions, The Learning Environment, Connections to Everyday Life, and Presentation of Topics.

Results

This section will show the items within the categories investigated that were statistically significant across the groups highest grade and lowest grade in high school mathematics classes. Unless stated differently, each survey question uses a scale from 1 to 5, with 1 being very rarely and 5 being every class. The error bars in the figures are evidence of the statistically significant difference across the mean responses of the items. Table 1 at the end of this section details each survey question and the mean values that were found for the highest and lowest reported mathematics classes.

Classroom Discussions

There were four items within the category of Classroom Discussions that showed a statistically significant difference between responses for students who received the highest and lowest grades in high school mathematics courses. Figure 1 shows the items: students were comfortable asking questions in class; students' questions and comments were valued; classroom discussions were useful; and teachers' answers to questions were valuable.

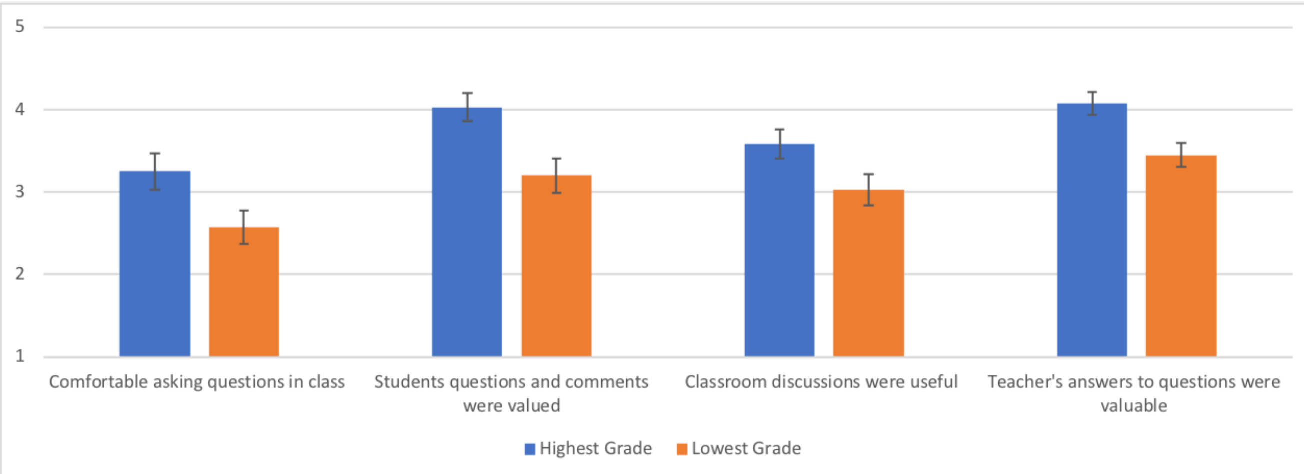

Figure 1: Mean Responses for Classroom Discussion for Highest and Lowest Grade in High School Mathematics Classes

The Learning Environment

Figure 2 shows the three items from the Mathematics Learning Environment that had a statistically significant difference between groups (highest and lowest grades) for the following questions: how often the teacher treated all students with respect; how often the teacher was disrespectful to students; and the percent of class time students were focused on learning. For the final question in this section—what percent of class time students were focused on learning—participants were given four choices, the value of 1 was assigned to the response less than 25%, the value 2 was assigned to the response of 25-50%, 3 was assigned to 50-75%, and 4 was assigned to more than 75%. The other two questions follow the same 1-5 scale described at the beginning of this section.

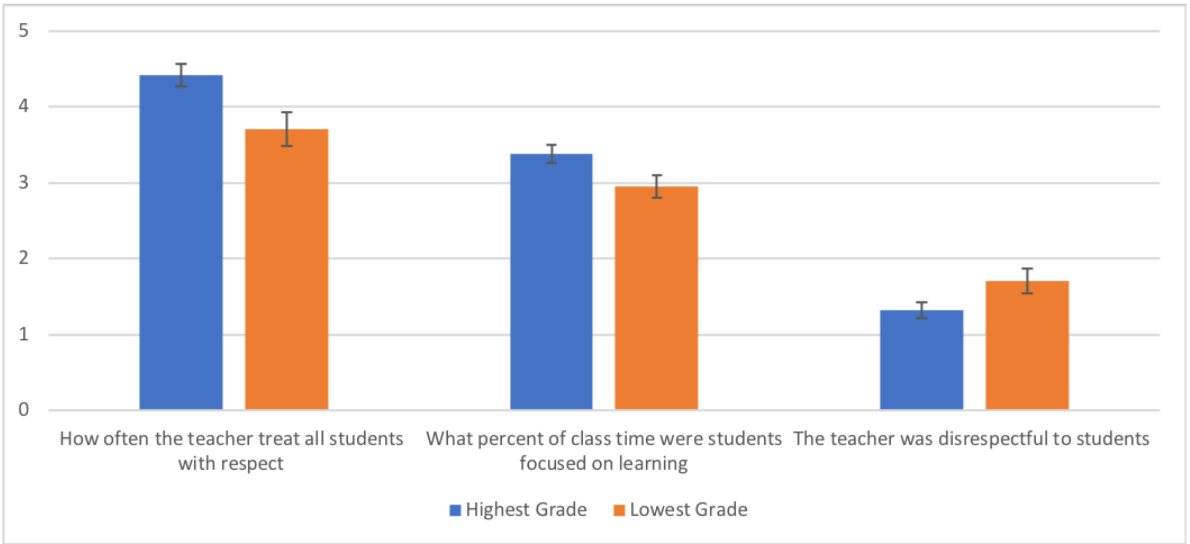

Figure 2: Mean Responses for Mathematics Learning Environment for Highest and Lowest Grade in High School Mathematics Classes

Connections to Everyday Life

There were five questions within this survey in regards to connecting mathematics in the classroom to everyday life outside of the mathematics learning environment that showed to be statistically different between groups. The Connections to Everyday Life questions are: how often the teacher connected math to the students' everyday life; how often the teacher connected math to real-life applications; how often the teacher connected math to other subject areas; how often the teacher told stories about people they knew that related to class; and how often examples from everyday life were used. Figure 3 shows these five items from the Connections to Everyday Life and how they compare to each other.

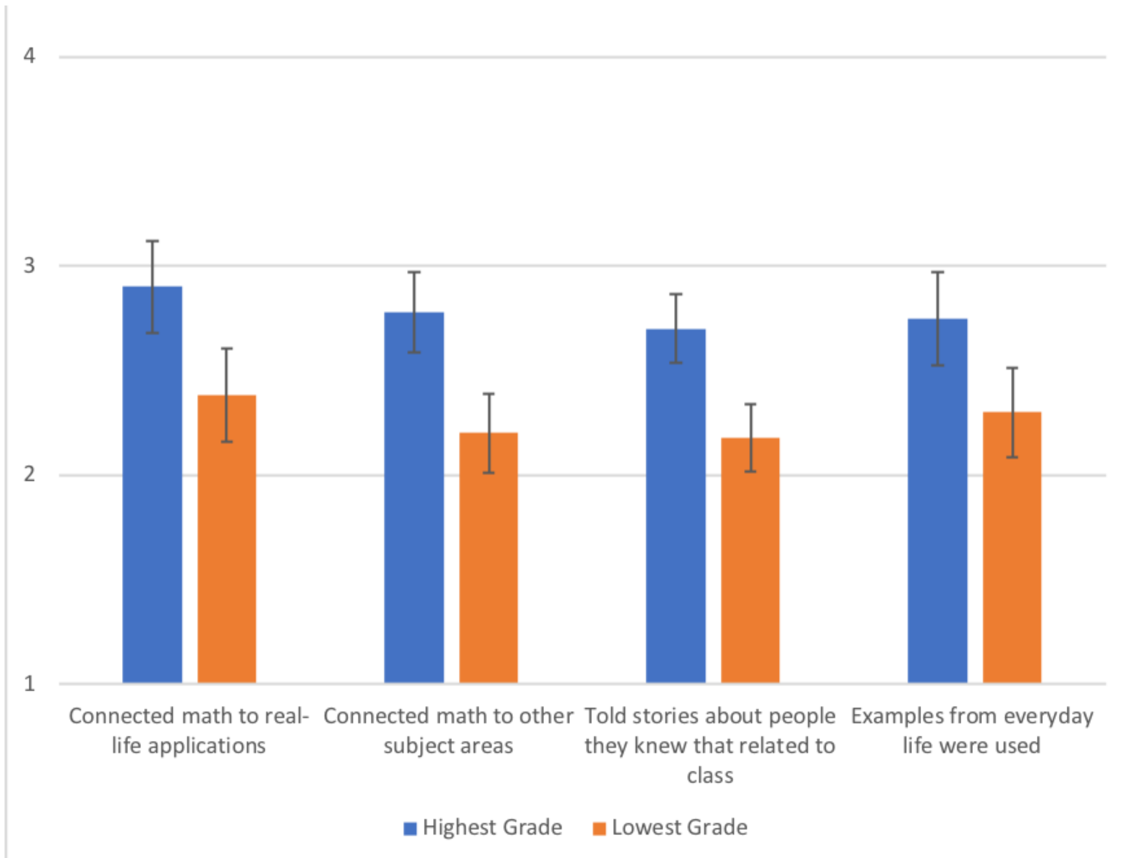

Figure 3: Mean Responses for Connections to Everyday Life for Highest and Lowest Grade in High School Mathematics Classes

Presentation of Topics

Figure 4 shows how Presentation of Topics relates to the two groups (high and low grades) for the following questions: how often the teacher highlighted more than one way of solving a problem; how often the teacher explained ideas clearly; how often the teacher used computer simulations or tablets; and how often the teacher used graphs, tables, and other illustrations in their lessons.

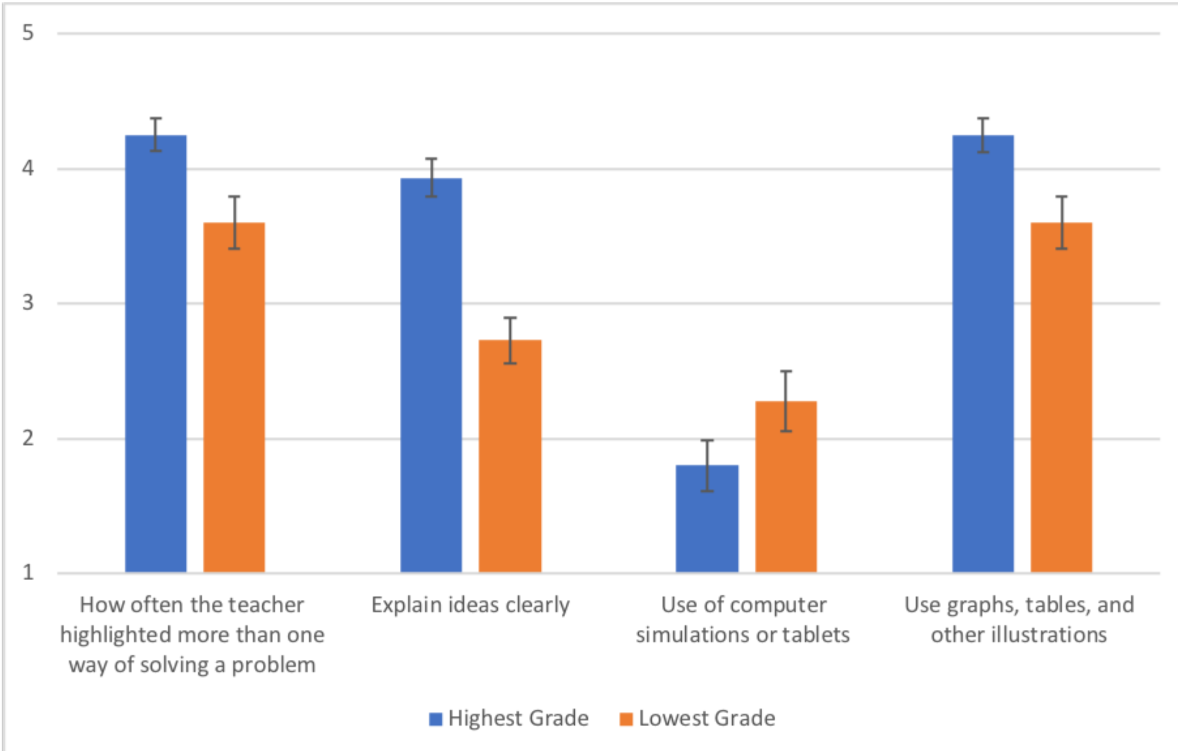

Figure 4: Mean Responses for Presentation of Topics for Highest and Lowest Grade in High School Mathematics Classes

Summary

Table 1 shows the way in which each question (item) that was found to have a significantly different mean was classified into each category. It shows the mean values and how significant the p-value was found to be between the highest and lowest grade.

Table 1

Categories with Standard Deviations and Statistically Significant Values of Mean Responses for Highest and Lowest Grades in High School Mathematics Classes

Category	Item	Mean	Standard Deviation
Classroom Discussions	Comfortable asking questions in class discussions	Highest: 3.25***	1.373
		Lowest: 2.58***	1.279
	Students questions and comments were valued during class discussions	Highest: 4.03***	1.074
		Lowest: 3.20***	1.344
	Classroom discussions were useful	Highest: 3.58**	1.130
		Lowest: 3.03**	1.230
	Teacher's answers to questions were valuable during class discussions	Highest: 4.08***	0.850
		Lowest: 3.45***	0.921
The Learning Environment	How often the teacher treated all students with respect	Highest: 4.42***	0.919
		Lowest: 3.71***	1.334
	What percent of class time were students focused on learning	Highest: 3.38**	0.740
		Lowest: 2.95**	0.932
	The teacher was disrespectful to students	Highest: 1.32**	0.650
		Lowest: 1.71**	1.055
Connections to Everyday Life	How often the teacher highlighted more than one way of solving a problem	Highest: 4.25***	1.030
		Lowest: 3.60***	1.091
	Connected math to real-life applications	Highest: 2.90**	1.392
		Lowest: 2.38**	1.409
	Connected math to other subject areas	Highest: 2.78**	1.209
		Lowest: 2.20**	1.181
	Told stories about people they knew that related to class	Highest: 2.70*	1.043
		Lowest: 2.18*	1.010
	Examples from everyday life were used	Highest: 2.75*	1.410
		Lowest: 2.30*	1.363
Presentation of Topics	Use of computer simulations or tablets	Highest: 1.80*	1.203
		Lowest: 2.18*	1.412
	Use graphs, tables, and other illustrations	Highest: 4.25**	0.776
		Lowest: 3.60**	1.215
	Explain ideas clearly	Highest: 3.93***	0.888
		Lowest: 2.73***	1.062

*: p<0.05; **: p<0.01; ***: p<0.001

Implications

Classroom Discussions

Based on the results from this survey, we can conclude that there is a statistically significant difference between the mean responses for high student performance and the four items as shown in Table 1. Although this has not been proven as a causal relationship, creating classroom discussions that emphasize these four aspects may help students perform better in high school mathematics classes. Some ways to make students feel more comfortable asking questions in class as well as make them feel that their input is valued include creating a time to allow students to ask questions, answering every question respectfully regardless of how obvious the answer may seem, and encouraging students to comment and ask questions when they feel they have something to contribute.

The Learning Environment

There are many ways for a teacher to create their personal mathematics classroom learning environment. The data from this study shows, as seen in Table 1, a statistically significant difference between three of the items addressing learning environment. This suggest that creating a classroom environment that fosters high performance through mutual respect is an important instructional practice.

Connections to Everyday Life

We discussed four items that were statistically significantly different regarding connection to students' everyday lives, as shown in Table 1. Thus, it seems beneficial for student learning and performance when mathematics teachers to make as many connections as possible between life outside the classroom and the mathematics learning environment. Some ways this can be done is by being more conscious of the example problems that are chosen to do as assignments and classwork. When a problem has numbers that make sense (such as quantities and measurements that would be realistic in a practical application), students are more likely to see the value of what they are learning to their own life. This increase in personal value may lead to an increase in student interest, and therefore student performance. The aspect of a teacher telling stories about people they know that relate to class is thought to be connected to higher performance in class because the students are not only able to see a specific example of when what they are learning was used in a real situation, but they are able to form a stronger bond between student and teacher since the teacher is letting the students see them as a person rather than just as an authority figure. Connecting mathematics to other subject areas has also shown to be beneficial. If students are able to see how mathematics applies to other subjects they may already be interested in, the student may in tern become more interested in mathematics and see a reason to increase their performance.

Presentation of Topics

There were four items with a statistically significant difference between the mean responses for high and low student performance, as shown in Table 1, regarding how material is presented in mathematics classes. The use of computer simulations or tablets is the only one of these questions that showed a higher mean between it and the lower performing class grades. This shows that there is a relationship between low performance in high school mathematics classes and the use of computer simulations or tablets. These responses were both low in quantity, meaning there were not many computer simulations or tablets used in any of the classes that were reported on, although those that were used created a statistically significant difference between the higher and lower performance. Therefore, this study suggests that there is not a benefit of using computer simulations or tablets when the goal is a higher-grade performance from students in high school mathematics. On the other hand, there is a different relationship between higher student performance in high school mathematics and teachers highlighting more than one way of solving a problem, explaining ideas clearly, and using graphs, tables, and other illustrations separately. These three ideas are aspects of teaching practices that support conceptual understanding. Therefore, implementing aspects of teaching from conceptual understanding frameworks that focus on using visuals and illustrations, as well as highlighting more than one way of solving a problem could lead to higher levels of student performance in high school mathematics classes.

Conclusion

Throughout this study, we have looked at four different aspects of the mathematics teaching environment and lessons: Classroom Discussions, The Learning Environment, Connections to Everyday Life, and Presentation of Topics. Each of these categories contain interest-based teaching practices that have significant differences in the mean responses between high and low grades received in mathematics classes. This leads us to believe that when students perceive their teacher respects them, it may lead to higher performance for those students. The aspects of interest-based teaching practices described in the above section should be highlighted by mathematics teachers that are looking to improve their student performance through their classroom and teaching practices.

In response to the COVID-19 pandemic, we should be wary of how drastically our teaching practices are changing. In some senses, our teaching needs updated, but we should make sure we aren't losing sight of the interest-based teaching practices that have been shown to have statistic differences when asked about levels of student performance. In this age of technology, it is important to keep students engaged through classroom discussions, respect for student input and ideas, connections between mathematics and real-life applications, and highlighting multiple ways of solving a problem. There is a lot going on in the world right now, but focusing on the aspects of teaching discussed in this paper may help both students and teachers navigate the rapidly changing educational environment.

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