Measuring Motivation within ST Math: After Two Waves, DISTRICT County

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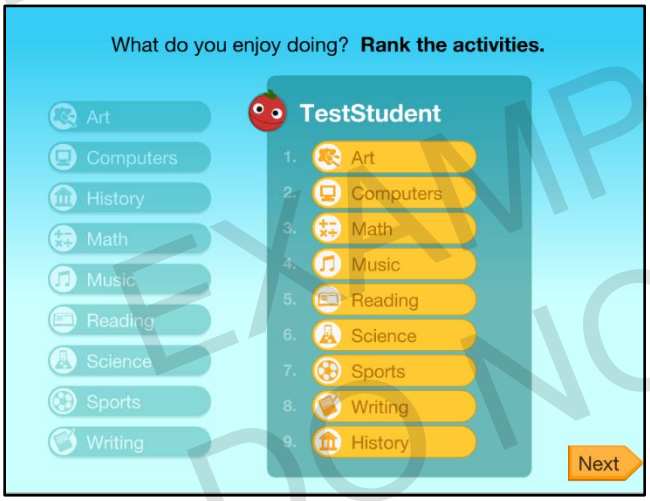
This document presents a report on student motivation surveys released through ST Math between Fall 2017 and spring 2018. Students included in this report completed the survey between July 19th and April 26th. Overall, 23,559 third through fifth grade students took the survey in DISTRICT. Within this report, data are presented on 13,012 fourth and fifth graders who were able to be matched with demographic data provided by the district from the 2016-2017 school year. Only those students who took two surveys, one in the beginning of the school year (July through October) and one after winter break (January through February) are included in this report.

Across both grades, included students are 50% female, 52% White, 21% Black or African American, 18% Hispanic, 5% Asian, and 5% Other Ethnicity or Multi-Ethnic. Sixty-two percent of students are eligible for free/reduced lunch, 13% have an identified disability, 12% are identified as gifted, and 9% are English Language Learners.

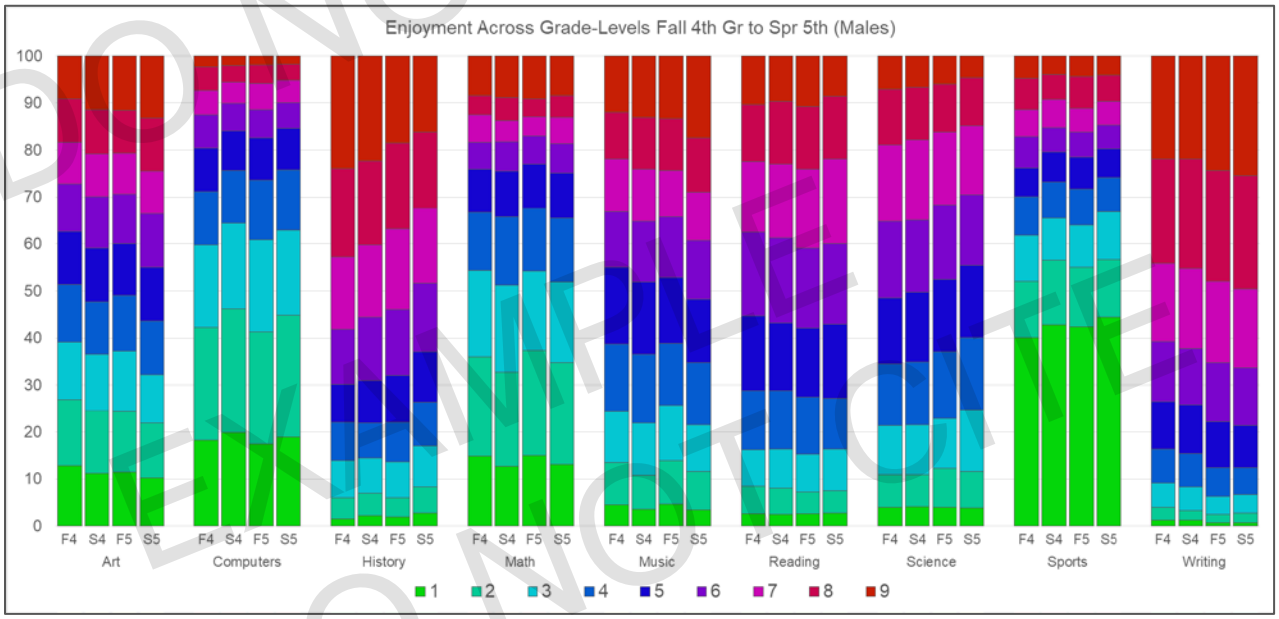
Enjoyment of Different Subjects

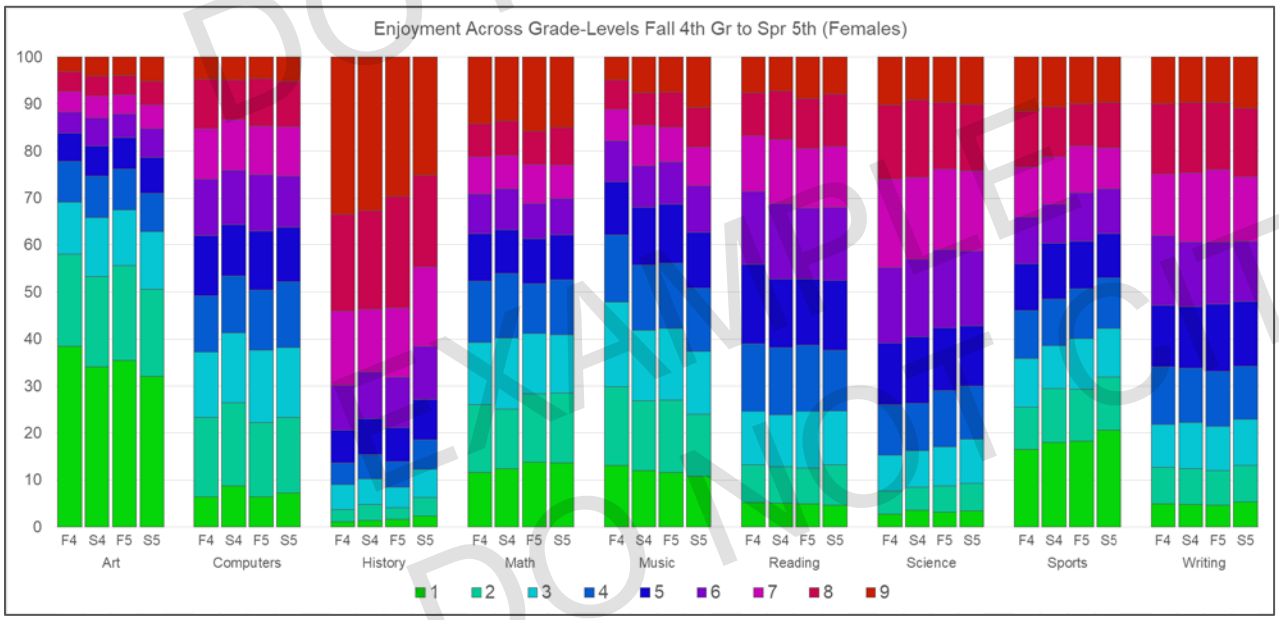


Students were asked to rank the nine provided subjects from most to least favorite. During the first survey, students chose 11,519 different orders of the possible 362,880 available permutations. The image at left displays the survey question with the second-most popular order choice, chosen by 15 students—the first-most popular choice was the default (alphabetical order), chosen by 72 students (0.5%). We suspect that most of these default order students either did not understand the question or did not wish to answer the question truthfully. During the second survey, there were 11,622 different orders chosen. The default was chosen by only 61 students, and the displayed order was chosen by eight students—now the third most popular order after the default. No students who chose the default order at Survey 1 also chose the default order at Survey 2.

Throughout the discussion of this question, we refer to answers as student *liking* or *enjoyment* of the specified subject. We view enjoyment as both a positive academic emotion and an element of intrinsic motivation; it has previously been related to achievement and self-concept (e.g., Gottfried, 1990). Enjoyment of math, in particular, commonly declines as students age (Gottfried, Marcoulides, Gottfried, Oliver, & Guerin, 2007). In the discussions below, four time-points are often presented together to suggest trends. It is worth noting that the fourth and fifth grade samples are different students—age and cohort effects from spring to fourth grade from fall to fifth grade cannot be separated. It may be that these differences are due to sample-specific differences; however, the consistency of most of these differences across the four participating districts within the grant and the alignment of results with theory bolsters are conclusion that we will likely be able to replicate these differences when we have longitudinal student data following the same child across grades.

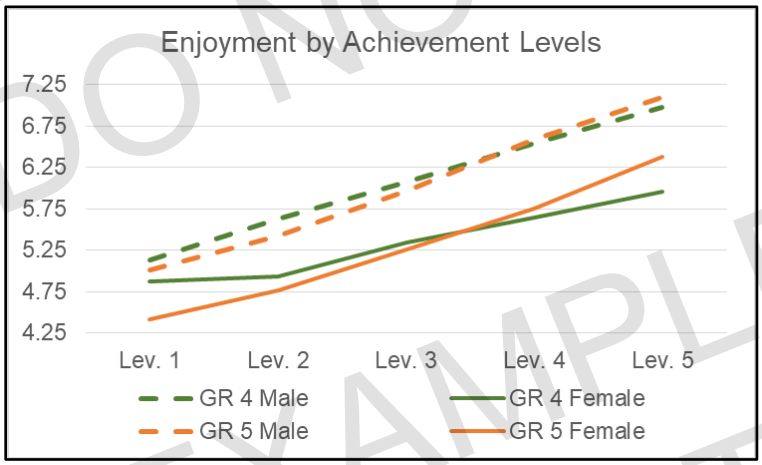
The graphs below display patterns of enjoyment by grade level. Patterns are separated by gender, as enjoyment of academic subjects, especially those associated with science, technology, engineering, and mathematics (STEM) are often reported differently by boys and girls (Su, Rounds, & Armstrong, 2009). Some similarities in the patterns emerge. History is the least-enjoyed subject averaged across surveys, with 25% of students ranking history last—represented by "9" or red in the graphs. This is not monolithic across genders. History holds the least-enjoyed spot for 30% of girls and only 20% of boys. For boys, writing is least-enjoyed—ranked "9" for 23% of boys and only 10% of girls. Art was the most-enjoyed for girls—35% ranked it a "1," represented by green in the graphs. Sports was the most-enjoyed for boys at 42%. Across grades, the relative position of art declines for both genders, with students in the fall of fourth grade liking art more than those in the spring of fifth. The relevant position of sports increases for both genders.





Considering math enjoyment specifically, enjoyment appears to remain relatively stable. It has an average ranking of about 4.7 across grades and survey times for girls and 3.9 for boys (reminder: lower rankings indicate more enjoyment). There is some evidence from the non-matched third grade data that enjoyment rankings are higher for third grade. This can be explored once the 2017-2018 district data is received and matched with the motivation survey.

In the graph below, enjoyment ratings are reverse-coded so that higher numbers indicate more enjoyment. The graph displays the relation between enjoyment and prior year's achievement level, from Level 1, Inadequate, to Level 5, Mastery, separately by grade and gender. Enjoyment appears to increase linearly with prior achievement for both boys and girls across both grades, but the relationship appears to be less linear for girls, who also express lower enjoyment of math overall.



It should be noted, however, that because the enjoyment question forced students to make relative rankings, the position of each subject is influenced by the positions of other subjects. Therefore, a class, school, or district that emphasizes another subject, such as science or computers, may have a relatively lower-positioned math enjoyment ranking. Other measures of value for mathematics (see below) can be used to better understand these results.

Importance for Future

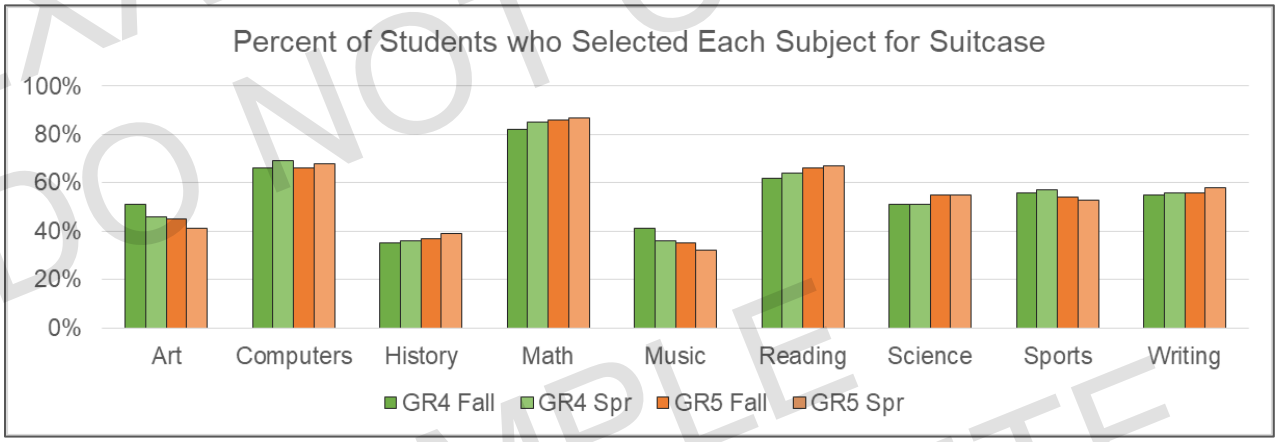
The question at right asked students to pack a suitcase with subjects they will need for their future. Although the box sizes were meant to indicate relative importance, interviews[1] indicated that children may not always be attuned to the different sizes. Future survey iterations can label the largest and smallest boxes "most" and "least" to prompt children to attend to size. Because of this lack of attention, we report only whether a student included a subject within their suitcase, not the position of the subject. This creates 126 potential choices of five of the nine subject options. The figure shows the most commonly occurring pattern.

This pattern of responses (history, math, reading, science, writing) was displayed in 834 students on the first survey and 860 on the second. The second most popular pattern on the first survey (computers, math, reading, science, writing) became the most popular on the second, jumping

[1] Interviews were conducted with volunteers at the NC State campus; interview participants are not part of the sample reported herein.

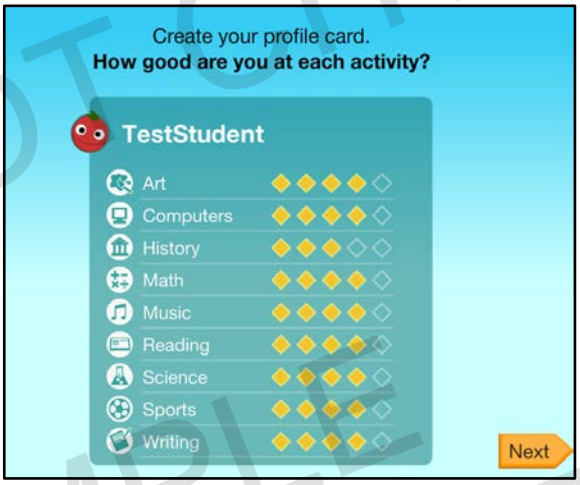
from 750 students to 895.

Examining selection of individual subjects paints a different picture than the patterns described above. Although the most popular pattern of subjects included the traditional academic subjects, among individual subjects, history was the least included in the suitcase, as shown in the figure below. This indicates that history was not a subject students saw as necessary for their futures. Conversely, math was chosen frequently and consistently. Math, as well as the other traditional subjects, history, reading, science, and writing, appeared to increase across surveys and grades, whereas art, music, and sports appeared to decrease in perceived importance for future.

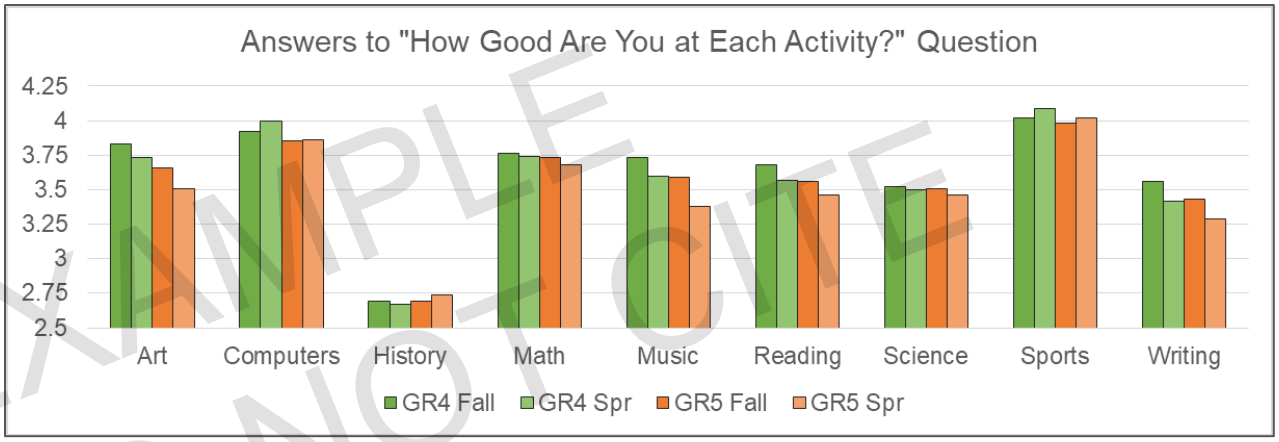


Self-Concept

The question at right asked students to choose between one and five diamonds to represent how "good" they are at each of the nine subjects. Overall, students were confident—796 students, 6% of the sample, selected the maximum confidence for every subject at the first survey. Only .07% of the sample—100 students, selected just one diamond for every subject. At right, the survey question is shown with the averages of each selected subject—history is the only subject with an average below 3.5 diamonds (shown as three diamonds at right); however, writing was a close second-lowest, at 3.5 diamonds, on average.

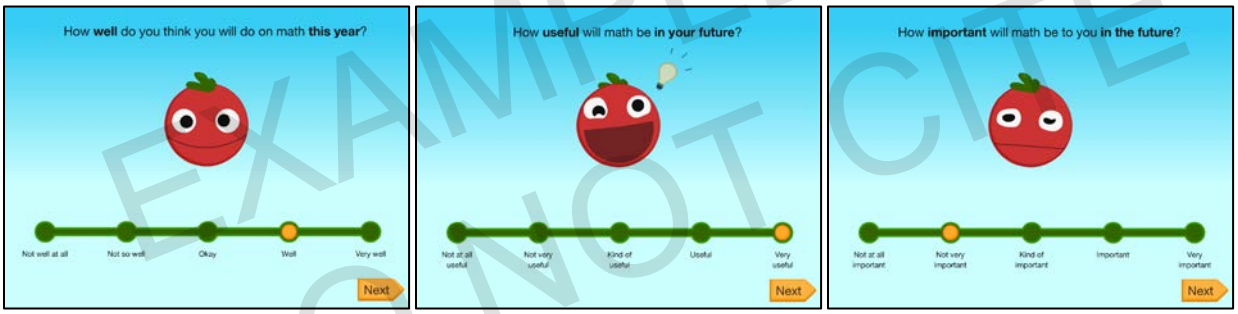


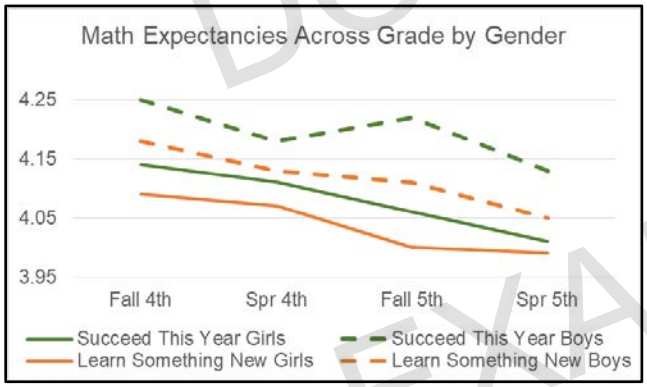
Averages for individual subjects are displayed by grade and survey attempt above. Although more fifth graders than fourth graders think math is important for their future (see suitcase question, above), student self-concept in math appears to decline from fall fourth grade to spring fifth grade. Self-concept for most other subjects appears to decline as well. Three exceptions are sports, computers, and history, which display inconsistent patterns. The computer self-concept of fifth graders appears lower at both survey points than that of fourth graders. Longitudinal data following the current fourth grade cohort to fifth grade will allow us to disentangle age and cohort effects. History self-concept is the lowest among all subjects.



Math-Specific Questions

Questions regarding expectancy and value for mathematics were designed to align with Eccles et al. expectancy-value theory, which focuses on student beliefs that they can do a task (expectancy) and how much they want to do it (value; Eccles, 1983, 2005). These questions were presented in a more traditional survey format with the addition of facial expressions to help students choose the appropriate response. Three examples are shown below: one of the two expectancy questions and two of the four value questions, future usefulness and importance.

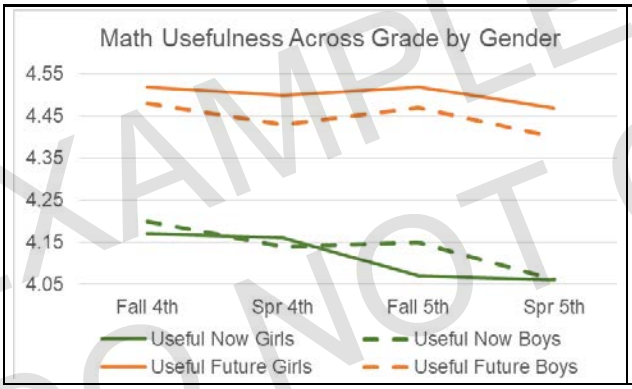


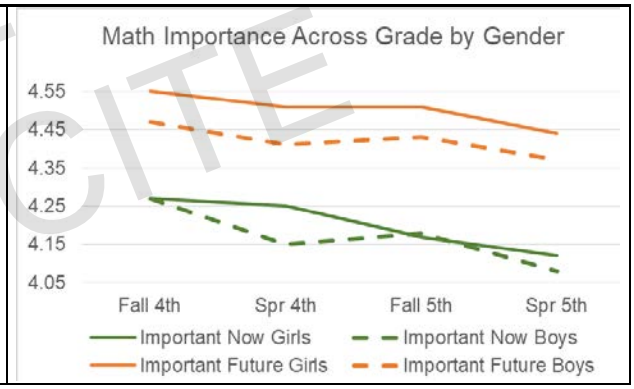


At left is a graph of student answers to the math expectancy questions, divided by gender. Echoing the answer patterns to the "how good are you at math" question above, student expectancy for success in math appears to decline across the surveys and grades—a decline in self-beliefs as students age is a common phenomenon (Wigfield & Eccles, 1994). Boys more strongly endorse the belief that they will succeed in the coming year in the fall of fifth grade than they do in the spring of fourth grade, not following the expected consistent downward pattern. Again, this is a pattern that might not hold longitudinally when the same students are examined across the grade transition. Girls' expectancy beliefs are lower than that of boys for both questions and across each time-point.

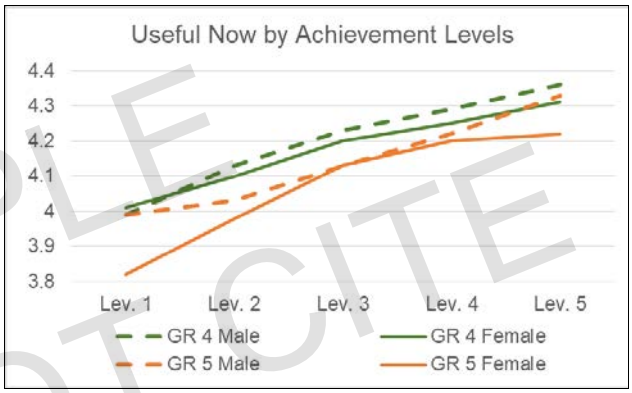
Below, similar graphs present data on math value (usefulness and importance), divided by gender. In contrast to what was seen with expectancy, girls report valuing the future usefulness and

importance of math at higher levels than boys report. Reporting of usefulness and importance of math for "now" is similar between boys and girls and appears to decline across survey time-points and grades, especially for importance; future importance also appears to decline.



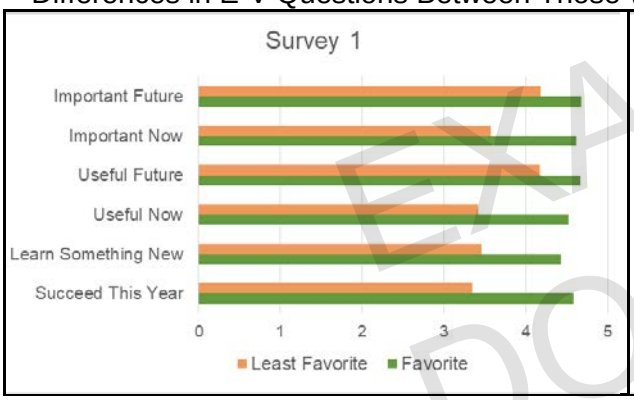


For both boys and girls across grades, students report math as more useful when they performed better in their prior year's math test, as shown in the graph at the right. Fifth grade girls who performed poorly in fourth grade report particularly low values of usefulness for math. Graphs for current and future importance and future usefulness show similar linear associations, but less extreme than that shown here. Once 2018 test scores are obtained, we can examine how value for mathematics may predict growth in math performance across years.



We can also examine differences in expectancies and values between those who rank math as their most enjoyable subject and those who rank math as their least enjoyable subject. Restricting the data to only these two groups produces the graphs below, one for each of the surveys. In each survey, roughly 14% of students chose math as their most enjoyable subject and 12% chose math as their least enjoyable subject. Of those who chose math as their most enjoyable subject in the fall survey, 50% chose math as their most enjoyable subject in the spring. Of those who chose math as their least enjoyable subject in the fall, 53% chose it as least enjoyable in the spring.

Differences in E-V Questions Between Those Who Rank Math as Most and Least Enjoyable



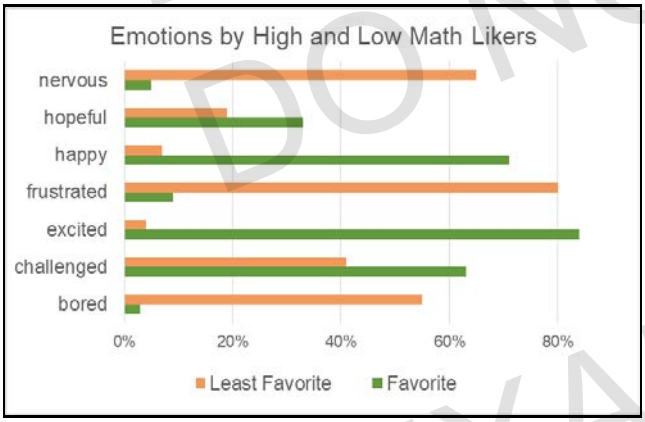
Those students who chose math as most enjoyable had higher levels of expectancy for math and utility and importance value for math. These differences were less pronounced when considering the importance and usefulness of math for the future—even students who did not indicate enjoying math as much as other subjects indicated that it was important and useful for their futures. As most of these students had lower expectancy for their own success in math, this might create conflict if students believe math is useful/important, but that they cannot succeed in it. It may be worth measuring more future-oriented expectancies for mathematics and probing in interviews to determine how students plan to become successful in math, if they do.

Emotions

The chart below displays the percentage of students who chose each emotion for math in the first survey. Students were permitted to choose up to three emotions, resulting in overlap between the emotions and 63 possible combinations of emotions. The most popular pattern was chosen by 16% of the students: challenged, excited, and happy. The second-most popular pattern was chosen by 10% of the students: excited, happy, and hopeful. At the second survey, the challenged, excited, happy pattern remained the most popular, still chosen by 16% of the students. The second-most popular pattern in the second survey was bored, frustrated, and nervous, chosen by 9% of students.

19%	59%	43%	34%	47%	37%	26%
						
bored	challenged	excited	frustrated	happy	hopeful	nervous

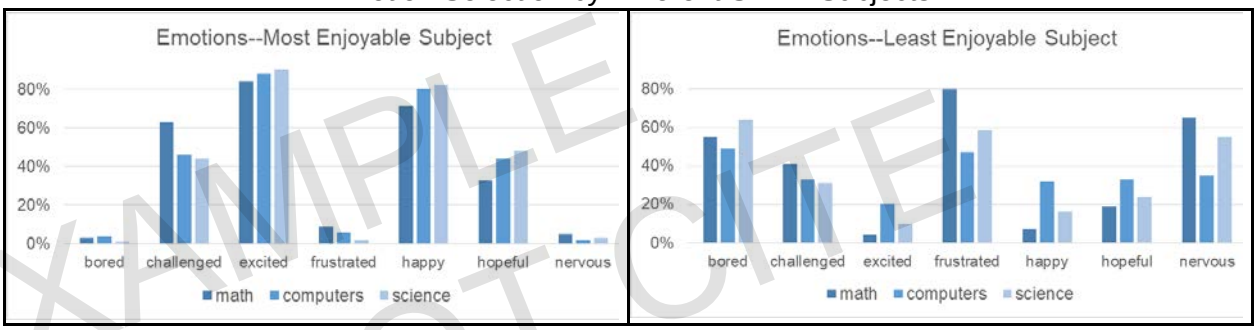
Overall, the students chose positive emotions to describe their experiences with math. As with expectancies and values, we explored emotions chosen among those students who selected math as their most and least enjoyable subject.



The figure at left illustrates the emotions chosen, divided by high and low math likers. Those who enjoy math least are more likely to select nervous, frustrated, and bored; those who enjoy math most are more likely to select happy or excited. Challenged and hopeful are selected by more students who enjoy math, but these emotions are still selected more often than happy or excited by those who do not enjoy math—challenged, especially, can be a positive or negative emotion depending on the situation. Among our interview participants, even those who report not enjoying math note that "challenged" can sometimes be positive for them.

We compare math emotions to those of other STEM subjects by limiting the sample only to those who selected math, science, or computers as their most or least favorite subject. Students who chose math as their most enjoyable subject note feeling challenged in math more than students who chose computers or science note feeling challenged in those subjects. The opposite pattern is seen with the emotions excited, happy, and hopeful. Fewer students who most enjoy math report these emotions in their favorite subject than do those who most enjoy computers or science.

Emotion Selection by Different STEM Subjects



Looking at students who chose one of these STEM subjects as their least enjoyable, students who chose math report feeling frustrated and nervous more than students who chose computers or science. Those who chose math or science as their least favorite report being bored in these subjects more than students who chose computers as their least favorite. As it was with the students who chose math as their favorite, students who don't enjoy math also report feeling challenged more in math than those who chose computers or science as their least favorite report feeling in those subjects. Lastly, even when computers is chosen as the least-favorite subject, students report feeling happy, excited, and hopeful more in computers than those who chose math or science as their least-favorite report feeling in those subjects.

What We Can Learn and Next Steps

These data present an initial snapshot of student motivation from July through April within DISTRICT County. Using these data in concert with other district data or information may illuminate potential areas of focus. For example, many students noted history as their least enjoyable subject. Districts may wish to investigate the history curriculum or the messages sent about the importance of historical study for students' lives. Regarding math, many students had high levels of value for math and experienced positive emotions during math. In particular, students reported high levels of perceived usefulness and importance of math for their future, even for those who had lower math self-concept or reported lower math enjoyment. What ramifications might this have as students experience the grade-level declines in math self-concept reported above?

In subsequent data collection, the same students will be followed across the year and into the next grade. This longitudinal data will allow us to make stronger claims about the changes in motivation students experience. In addition, analyses will be conducted to relate student motivation to other gathered metrics: a larger collection of student background characteristics, achievement outcomes, and game-play and other choices within ST Math. In this way we will be able to identify which patterns of motivation may be most adaptive and for whom. We recommend some changes to the survey to assist with these analyses: clarifying the suitcase rankings for most and least important as noted above, asking about far future math expectancies, and potentially adding a question about interest to the expectancy-value questions that does not rely on relative enjoyment of math compared to other subjects. In addition, it may be informative to ask students to enter their future career goal. Our interviews indicate that these goals drive the way the students answer the questions regarding usefulness and importance and may allow us to contextualize many of the answers and provide potential avenues to explore toward improving student motivation. Our interviews also indicate that students would like their teachers to know answers to their motivation survey—many note believing it would improve their relationship with their teacher—an important

element in student engagement (Furrer, Skinner, & Pitzer, 2014). We are open to working with the district to help facilitate this sharing.

Although the current data provide rich information on student motivation within DISTRICT, the best insights may come from those with intimate knowledge of the workings of the district and schools. As such, we welcome conversations with district personnel about these results and future analyses. In addition, we welcome questions from those most knowledgeable about the participating students—by working together, we can ensure that our project answers meaningful questions and can be translated into action to assist teachers and students.

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