CENTRALITY OF MATH IN STEM

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Table of Contents

Abstract

In STEM the Tide, author David Drew references a quote that "it takes fifteen years to create a scientist or advanced engineer." This suggests a student will likely commit to the field of STEM at around sophomore year of high school. Given the importance of education, educators are always looking to foster engagement for STEM within their classrooms. In order to observe such engagement, this study involves a week-long, group-based STEM project implemented for students at a grade-appropriate level, in addition to a survey which investigates whether engaging students in project-based learning with grade appropriate math material can impact student engagement in math. At the conclusion of the study, data was gathered which confirmed that while students were willing to form good work habits in regards to mathematics, factors such as lack of confidence proved to be a key psychological factor for those that wished to pursue mathematics further. Although there remain some concerns regarding communication aspects such as student cooperation. Nonetheless, the benefits and potential for student engagement via project-based learning is enticing for educators to strive towards.

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Chapter 1: Background

STEM education in the US has been on a rapid ascension in the recent decades. Since the late twentieth century, “knowledge workers” that graduated with STEM-related degrees are working jobs which require higher education knowledge. In his book, STEM the Tide (2011), author David Drew points out that the technological boom of the late twentieth and the early twenty-first century have greatly increased the demand for knowledge workers in our workforce. Those workers essentially take up same proportion in the workforce that blue-collar workers did in the early-mid 20th century (p.55). This shift in worker background requires the continuous support for the volume of knowledge workers that enter the industry, for now and later. This becomes the new challenge to maintain, as we need to ensure that those workers are qualified for the job with a proper education. As such, David Drew recognizes that the need to improve education is the utmost priority to keep the US amongst other innovative giants in the world. In order to do so, the process begins from the ground up through our education system. Drew proposed an outline with three main steps for educational reform (p. 55-76).

- Holding accountability for higher expectations in the classroom.
- Hiring ‘top notch’ teachers to reinforce those expectations in the classroom.
- Improving upon outdated teaching methods in the classroom and promote group-learning experiences amongst students that resembles the experience of working in a real-life industry job.

The aforementioned steps have already been implemented and realized in various forms in the state of Massachusetts.

Statewide Efforts in Improving the Quality and Standards of Mathematics Education

In terms of holding accountability for higher expectations in the classroom, Massachusetts has certainly followed suit. The Massachusetts Education Reform Act in 1993 was passed to improve the quality of education throughout statewide classrooms. The Common Core was at the head of these changes, and this system provided unifying statewide standards to ensure the quality of the main academic subjects taught in classrooms, which includes mathematics, science, language arts, and foreign languages. This change proved to be the most significant as physical education and history were no longer the only classes subjected to a statewide set of standards prior to the Act. Furthermore, this Act brought forth two other changes in the classroom that contributed to a brighter future for education in Massachusetts.

The first change became the Massachusetts Comprehensive Assessment System (MCAS), which served as a standardized test for third to tenth graders. The Act also mandated that all high school students must pass the tenth grade MCAS test as one of the requirements for graduating high school. Overall, the results from these tests would contribute towards a scale to assess district performance to ensure that schools were meeting the higher standards introduced by the Common Core.

The second change sought to improve the quality of our teachers by requiring teachers to pass the MTEL tests appropriate to their field, along with an additional test in literacy skills to ensure that teachers were fully qualified to teach in their classrooms. Since the teachers already hired were not exempt from taking the MTEL test, the Act ensured that those experienced teachers would need to prove their qualifications via an official test, to indicate that they were well-prepared to teach their classes, or otherwise, signaling the need to brush up on their content knowledge. Furthermore, the MTEL became a necessary barrier of entry for novice teachers to prove that they were well-qualified as well. The push by the MTEL to demand for qualified teachers in our classrooms is certainly a good step forward, which leads to David Drew's next point of emphasis.

'Top-Notch' Teachers

Regarding teachers in the classroom, Drew's main point of emphasis is to attract quality college graduates to teaching, while so providing them with meaningful training, and keeping those aspiring teachers from quitting. This is still a notable hurdle to overcome, mainly due to the high costs of attending college, alongside the looming pressure of repaying student debts, and the low starting salaries of teachers which turn away many students who are concerned about their financial situation after graduating. Furthermore, there is a lack of respect given to teachers in classrooms, whether it is coming from rebellious students, or parents who are more inclined to scapegoat teachers for their children's struggles in schools. (Krajewski, 2016) Altogether, one could perhaps see this as a lack of respect to education itself, and as a result the aforementioned factors create a troubling stigma around the profession of teaching.

Nonetheless, David Drew advocates for the recruitment of top students through training programs at institutes in master's programs, while awarding four-year scholarships for high school students getting into teaching. Drew believes this initiative as a "worthwhile investment" because recruiting 10,000 teachers could impact 10 million minds in return (p. 104).

Local Efforts in Improving the Quality of Teachers

In Worcester, WPI is doing its part in contributing to the efforts in "combating the nation's math teachers shortage." As a prominent STEM school, WPI will certainly agree with the emphasis in providing top quality education in the fields of mathematics, science, technology, and engineering. At the beginning of 2019, WPI has reduced the tuition of its Masters of Mathematics Education program by nearly 40% to encourage teachers in their pursuit of teaching master's degrees. For vice president Kristin Tichenor, she believes that, "WPI's MME program fills a critical need for math teachers in the U.S… The challenge is that teachers typically have limited funds available for professional development. WPI made the decision to radically reduce the cost of the program so that more teachers would have the chance to participate in this highly valued degree program."

Likewise, Professor John Goulet, Coordinator of the MME program, is encouraged by the increase in recent enrollment, as he advocates for adjusting "our cost [of the program] to their financial realities." and Goulet sees this as an opportunity to continue to uphold the "service we provide to the K-12 community."

Confronting and Improving upon Outdated Teaching Methods

There are also areas of concern about the methods that various mathematical subjects are taught in our classrooms. As a statistics professor at UCLA, David Drew is rather critical of such issues, especially concerning how statistics is taught in our universities, where the professor writes information on the board while the students mindlessly copy in the interest of time and the fast pace of lectures. Furthermore, Drew keys in on the lack thereof in terms of attentiveness from his students. He demonstrates his concerns with how students are retaining information from lectures and remarked, “Once after giving a lecture to 200 UCLA undergraduates, I described to a colleague the range of student behaviors I observed. Some students had listened attentively, others had slept, snapped their chewing gum, sipped coffee, read a newspaper, joked, or [flirted with one another].” As a result, Drew argues that the key to engage student learning was to “not teach isolated techniques, but to embed student learning in real life projects” (p.97). Drew came to such a realization after a meeting with Dave Master, who taught animation at Rowland High School in a blue-collar, multiethnic neighborhood near the Los Angeles area. Master was selected as the IBM/Technology and Learning National Teacher of the year for his work in 1991. In that meeting, Drew also spoke to quite a few former students of Master that now work in the field of animation. (p. 96) The success stories were overwhelming, there was a near dropout student who had run-ins with the law who ended up winning three Emmys. There was another student named John Ramirez who became a highly successful animator and theme park designer for locations in Asia and US. Mr. Ramirez remarks, “Without [Mr. Master’s] class, we felt real ownership, it was our program. If I walked into a math class, it was my teacher’s class.” There were other former students that ended up working at companies such as Disney, Warner Bros, Pixar, Valve, and many other holding positions in the film/television industry.

Intrigued by these success stories, Drew asked Master for his guiding principles in his success in the classroom. Master responded with, “What you teach is not as important as how you teach it. The key is not to teach isolated techniques, but to embed student learning in real life projects…the students find this more relevant and engaging, less contrived and abstract. They became part of a field; this built a bridge to industry.”

Developing Number Sense

In terms of learning in the classroom, research by Professor Jo Boaler (2015) of Stanford suggests that memorization is a problematic approach that harms a student's willingness to be more flexible in the problem-solving process. When students become dependent on memorization in stressful situations such as a test, the hippocampus, which is responsible for memorizing facts, becomes blocked and essentially prevents the students from effectively recalling their knowledge.

Boaler advocates that the best way for students to learn mathematics is through using number sense regularly and frequently, as doing enough repetitions from practicing number sense becomes the foundation that sets up students for better success, especially in higher level mathematics. In her work, Boaler loosely defines number sense as the ability of a person to understand a problem through intuition. (Boaler, 2015) A concrete example of number sense as quoted by Boaler is, "When asked to solve 7x8, someone with number sense may have memorized 56, but they would still be able to work out that 7x7 is 49, and 7 added on makes 56."

Boaler also suggests that "math fluency" is often misunderstood for speed, rather than accuracy. On that note, Boaler mentions that some of her other colleagues in the field of mathematics are rather slow in their problem-solving process, as they choose to "think deeply and carefully about mathematics."

Confidence in the Classroom

Confidence, as defined by Albert Bandura, is having the "self-assurance resulting from a belief in one's own ability to achieve things." Similarly, Bandura defines self-efficacy as "not a measure of the skills one has, but a belief about what one can do under different sets of conditions with whatever skills one possesses" (Bandura, 1977). With those two factors in mind, Bandura believes self-efficacy to be the primary psychological factor that influences student performance and achievement in the classroom. Ultimately, the level of the student's self-efficacy will impact student's capability to fulfill and succeed the tasks given to them (Bandura, 1986).

Decline in Interest in STEM in Relation to Confidence

Researchers have pinpointed that STEM interest declines as a child grows older (Haladyna and Thomas (1979)), this is in large part due to factors such as motivation and positive attitudes towards the material students are learning in the sixth to seventh grade range. (Epstein & McPartland, 1976; Klarier, 1981; Marsh, 1989) While many researchers have acknowledged puberty and cognitive changes in the brain as factors that impact student self-esteem, Eccles et al. (1993) discovered that levels of student self-esteem were quite stable for the sixth-grade school year in their results. But those levels of self-esteem dropped quite dramatically in a short span of time as the students made the transition into the seventh-grade school year.

Eccles's group sought to investigate this issue through the viewpoints of teachers as well. In their work analyzing trends in southeastern Michigan middle schools, they had found that the change in philosophies between elementary (noted to be sixth grade and below) and middle school (above sixth grade) teachers to be another contributing factor to lower self-esteem within students, specifically, middle school teachers were prone to providing fewer self-efficacious decision-making opportunities to their students in their learning compared to the elementary school teachers. A large reason for this disparity between the surveyed sixth and seventh grade teachers were due to seventh grade teachers believing in stricter discipline was needed for their students significantly more so than their sixth-grade counterparts. Furthermore, those seventh-grade teachers rated their students to be less trustworthy than sixth grade teachers would have for their students. Thus, it was not a surprise that seventh grade teachers felt less efficacious than sixth grade teachers, as behavioral and maturity issues became a significant factor in their rather cynical assessment of seventh grade students compared to sixth grade students. As a result of the lower levels of support provided by the teachers, students began to lose interest in the subject matter, thus valuing the importance of math less in the span of two years of Eccles's study.

This decline in confidence was even more prevalent amongst girls compared to boys. Orenstein in 1994 found that girls in elementary school performed just as well as boys but overtime the decline in confidence impacted girls in their likelihood of retaining interest in the STEM subjects. The deficit in performance in those subjects began at 13 and eventually grew to larger gaps by the age of 17, and it was concluded that the middle school years are in fact, the catalyst years that started the declining levels of confidence amongst girls (Orenstein, 1994). Stemming from this decline in confidence, girls become less and less likely or willing to take advanced STEM course offerings (Sanders and Nelson, 2004). This culminates into the underrepresentation of women currently in the STEM workforce. In fact, the US Department of

Commerce, Economics, and Statistics Administration reported in 2015 that women are only holding approximately 24% of all STEM jobs available. This is a rather unfortunate circumstance as the wage gap between male and females is rather smaller in STEM related careers than the rest of the other fields, with women in STEM fields earning as high as 35% more than the women not working in STEM fields**.**

Fostering a Project-Based Learning Environment

To address the aforementioned concerns about the quality of STEM education, teachers can look to boost the confidence levels with their students, to foster an interactive and engaging learning environment in the classroom by implementing a project-based learning approach in their lesson plans, and ultimately, promoting a life-long learning approach that impact students even beyond their initial school years.

When taking the first step to creating an engaging learning environment among student groups, one must also consider the dynamics of student abilities within such groups. Through his research in 1992, Professor Jonathan Tudge of UNC-Greensboro suggested that pairing higher achieving students with lower achieving students can benefit the former for tasks that require higher critical thinking (Tudge, 1992). Tudge also issued a pre and post-test to measure student performance, and the results demonstrated that the lower achieving students performed significantly better on the posttest with student pairings compared to a pretest without pairings. Thus, Tudge was able to conclude that the exposure to group work allowed students to improve by learning from “another of greater competence” (Tudge, 1992).

Fostering a collaborative environment between students is exemplified by implementing a project-based learning approach in classrooms. This approach encourages students to work in pairs to tackle problems with real life applications. In this case, teachers do not have to lecture at a board to effectively carry out a lesson, but rather becoming "facilitators of inquiry." In doing so, teachers can design then assign inquiry-based tasks to students, which will often prompt students to conclude their learning experience with a "product or artifact" (Barron & Darling-Hammond, 2008; Thomas, 2000).

This project-learning approach is supported by research from Johannes Strobel and Angela van Barneveld, both of whom had suggested that project-based learning can improve long term retention for many students (Strobel & van Barneveld, 2009). Moreover, project-based learning can provide additional benefits in giving students opportunities to complete hands-on applications, while improving student cooperative abilities amongst themselves, and providing a boost in confidence for students in the learning process.

Confidence in Relation to Self-Efficacy

Similarly, Degenhart and her group (2007) advocates for better, authentic instruction by teachers. This is done through cooperative group-work that increases the self-efficacy levels of all types of students. In regards to the meaning of self-efficacy in this context, Degenhart references work done by Frank Pajares of Emory University, who had worked on a meta-analysis of self-efficacy research (Pajares, 1996) to discover that people will generally partake in activities that they feel successful or confident in, while avoiding activities that they do not feel confident in. A large factor for such success comes from a person's self-efficacy levels, the greater it is, the more likely the person is to be resilient and persistent when undertaking the activity. Meanwhile, those that had low self-efficacy viewed problematic activities to be harder than it was. Pajares elaborated further about gender in relation to efficacy levels, upon examining the levels of self-efficacy amongst middle school students in algebra classes after a test, Pajares discovered that girls tended to have lower confidence when their performance scores did not warrant it, and still had lower confidence than boys even when their performance scores did warrant better confidence. Altogether, Pajares found that while boys were biased towards overconfidence of their performance, on the other hand, even the gifted girls of the group were more biased towards under-confidence.

Degenhart and her group advocates for group work as a way to provide mutual learning opportunities that not only encourages the positive students to reinforce their knowledge by relaying information to help others, but also offering a scaffolding mechanic for negative students to catch up, thus improving their self-efficacy levels as well. This is also supported by Professor Carol Colbeck of the University of Wisconsin, who concluded that "students are more likely to experience their own accomplishments, engaging in active, hands on learning experiences rather than passively listening to lectures." (Colbeck et. al, 2000)

On a related note, this is also supported in part when Drew (p. 113) references the research done by Professor Uri Treisman at Cal Berkeley, in his work understanding the efficacy of students and their study habits. Treisman was inspired when he encountered one of his students, an African American student who had a difficult upbringing in East Oakland, but was very active in his high school activities, became president of his graduating and ended up attending Berkeley. Unfortunately, the student struggled right away in the fall term of his freshman year. The student decided to cut all means of social interactions to devote all of his time to studying for the winter semester, but this was to no avail as he struggled again on his winter midterms, and ultimately withdrew after the end of his freshman year.

Treisman had taken much interest in the case of the student and designed a case study to investigate further. Treisman interviewed twenty African American students from the upcoming class, alongside another group of twenty Chinese students. (Drew p.115) He then inquired about those students' study habits for their Calculus classes in terms of hours spent per week, who the students worked with together (if at all) on homework, and specifically, their willingness to attend office hours. Treisman even went a step further to obtain permission from several students in both groups to observe them while studying, and he came away with fascinating results.

Treisman found that the Chinese students were eager to set up study sessions with their friends, the opportunity in doing so allowed the students to critique each other's work to correct mistakes, clarified topics they were unsure on, and most importantly, the extra perspectives allow them to often find multiple innovative solutions to the problems. On the other hand, he found that the African American students were much less willing to work with their peers in groups, often opting to work independently. This was a curious choice, but Treisman realized that most of them had graduated top of, if not, close to the top of their classes in their respective high schools. This independence mentality led them to believe that seeking help from fellow students was a sign of weakness, which would lead others to label them as under-achieving students.

To address this issue, Treisman hosted a workshop starting in the 1978-1979 school year and welcomed students of all ethnicities to participate in. The workshop's primary goals were to help students realize the emphasis in seeking collaborative learning in small groups to better understand the material learned, in addition to helping minority students overcome their pre-disposed stigmas of seeking help to not just avoid failure, but to excel. For his work at Cal Berkeley, and the spread of programs similar to his workshop to other universities, Treisman was recognized by the Harvard University as their 2006 Scientist of the Year.

Through his work, Uri Treisman made it evident that student work in groups became the catalyst in improving student performance at Cal Berkeley, as collaboration allowed students to bounce ideas off each other, correct each other and provided the benefit of seeing different approaches. In doing so, students can navigate through a problem with additional perspectives. Treisman sees student collaboration as one of the best tools to overcome the student achievement gap, not just at the university level, but also at elementary to high school levels.

To further understand the process of cultivating classroom engagement for students, one must look to understand the attitudes of the students themselves. With that in mind, in STEM the Tide, David Drew references a quote from author Thomas Friedman, that “it takes fifteen years to create a scientist” (Drew, 2011, p. 19). Thus, the goals of this study are to explore the extent of this quote in context of student feedback, alongside understanding the levels of classroom engagement in terms of student attitudes towards mathematics and feedback towards group-based project learning in general.

Chapter 2: P. Brent Trottier Middle School Overview

The participants of this study are from the P. Brent Trottier Middle School, a public school located in Southborough, Massachusetts. PTMS has an enrollment of 431 students as of the 2018-2019 school year, ranging from grades six through eight as indicated below.

Enrollment by Grade (2018-19)																
	PK	K	1	2	3	4	5	6	7	8	9	10	11	12	SP	Total
District	82	111	133	124	134	129	129	136	152	143	0	0	0	0	0	1,273
P Brent Trottier	0	0	0	0	0	0	0	136	152	143	0	0	0	0	0	431

Figure 1. PTMS Enrollment by Grade Data

Race/Ethnicity	School	District	State
Total # of Classes	290	481	453,583
Average Class Size	16.1	16.8	18.1

Figure 2. PTMS Class Size Data

Enrollment by Race/Ethnicity (2018-19)			
Race	**% of School**	**% of District**	**% of State**
African American	0.2	0.9	9.2
Asian	17.6	18.9	7.0
Hispanic	5.3	4.8	20.8
Native American	0.0	0.2	0.2
White	72.2	69.7	59.0
Native Hawaiian, Pacific Islander	0.0	0.1	0.1
Multi-Race, Non-Hispanic	4.6	5.5	3.8

Figure 3: PTMS Enrollment Data

At the time the enrollment data was collected, PTMS consisted of 136 total sixth graders. On average there are 16 students in each class, which is similar to respective district numbers, but a bit fewer than the average class size in the state.

In terms of enrollment by race, P. Trottier Middle School comprises mainly of white students, which is followed by Asian and Hispanic students combining for a large portion of the minority ethnicities at roughly 23%, then African American and multiracial students combining for the last 4.8%. The percentages of ethnicities in PTMS similarly reflects the percentages of the ethnicities represented in the Southborough district in general. However, compared to the enrollment data of all students in Massachusetts, PTMS has a higher portion of white and Asian students, and on the contrary, fewer portions of students of Hispanic and African American descent relative to the rest of the state.

Enrollment by Gender (2018-19)			
	School	District	State
Male	224	652	487,594
Female	207	621	463,816
Total	431	1,273	951,631

Figure 4: PTMS Enrollment by Gender Data

In terms of gender, PTMS has slightly more male (51.97%) students than female students (49.03%), and this is on par with the slight gender disparity in the district (51.2%) as well as the state (51.2%).

Title	% of School	% of District	% of State
First Language not English	12.1	13.4	21.9
English Language Learner	4.2	6.1	10.5
Students With Disabilities	13.2	15.6	18.1
High Needs	24.4	26.8	47.6
Economically Disadvantaged	4.9	5.5	31.2

Figure 5: PTMS Selected Student Populations

Looking at the school's selected populations, nearly a quarter of its students identify as high needs, and students with disabilities or first language not being English combine for another quarter. Meanwhile, the English language learner students and economically disadvantaged students make up for another approximate 9%. In comparison to the state, the school's selected populations above are slightly smaller than the district's selected populations across the board. However, when compared to the rest of the state, PTMS had significantly fewer high needs, economically disadvantaged students, in addition to having moderately fewer students that were either ELLs or not having their first language as English.

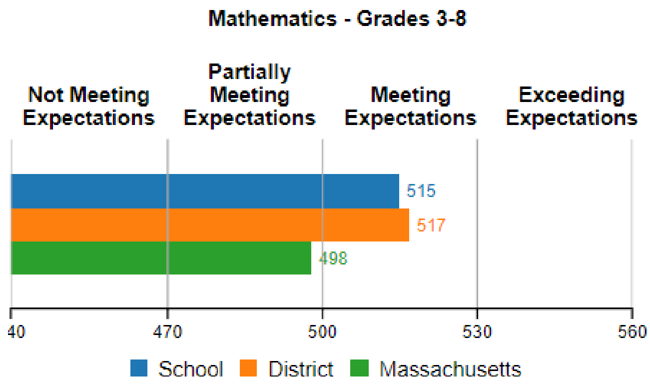

Figure 6: PTMS MCAS performance relative to district and rest of state

Looking at the school's MCAS performance, it is firmly in the meeting expectations category, performing almost on par with that of other schools within the district, and ahead of other schools in Massachusetts by a moderate margin. As of 2018, the school is partially meeting targets on the School and District Accountability scale. In its vision statement, PTMS advocates for "High expectations, creativity, critical thinking, and inquiry to shape its learning environment."

Chapter 3: Methodology

For the purposes of this study, Mrs. Laura Folsom and her group of sixth graders agreed to collaborate on a week-long project during their Technology Education class. The project features grade level appropriate content focusing on a city-themed set of mathematical problems that students were expected to solve individually, as well as collaboratively in groups.

Project Overview

The project encompasses five lesson plans that spanned approximately a week and a half worth of material depending on pacing and class length. The material in the lessons provide opportunities for students to review on their knowledge on topics such as conversions, unit rates, distance formula, area, and perimeter. The portions of the lessons not implemented (intended for eighth grade) would have asked students to graphing functions, identify relationships between those graphs, interpret rates of growth on those graphs and having an introductory look at regression. The project in its entirety is based on a STEM-mathematical theme based upon various aspects of a city and aims to provide coherent and grade appropriate level material in a group project-based learning experience.

To accommodate Mrs. Laura Folsom's students, class schedule and available time in her curriculum, the project was adjusted to focus on having the student groups create the map and the transit stops portions. The sections omitted include a lesson on researching and managing the finances of a make-believe franchise within the city that the student groups received from a randomly drawn lot. The final omitted section involved a problem modeling a flu outbreak onto a graph which was originally intended for students of eighth and ninth grade level. The lesson plans of the omitted activities can be found in Appendix C: Lesson Plans.

As for the portion of the project that was implemented, students were split into pairs to create a city map within their groups. Given the classroom configuration (which consists of four large worktables), there were often two groups per table, and the total amount of groups ranged from about five to eight in smaller sections, to nine or more in larger sections. In terms of how the groups were formed, Mrs. Folsom had every student come up with a list of four classmates he or she would like to pair with at the beginning of the school year. Then based on her own data and grades of her students, Mrs. Folsom would try to ensure that every group has one high achieving student who can aid a lower achieving student as much as possible. In addition to ability, Mrs. Folsom likes to pair up students with similar personalities, so for example two students with stronger personalities (often outspoken) would be paired together, and vice versa for the more reserved personalities. This is done to avoid outspoken students dominating discussions with more reserved students. It is certainly an interesting dynamic to consider alongside ability.

The goals of the project were stated as follows, *"...Your goal is to create a map that closely reflects the landmarks you would expect to see in a real-life city. In addition, you and your group are also tasked with creating a transit system that traverses through the city to complete the challenge. While doing so, be mindful of your map's dimensions, as well as the placement of your transit stops."*

The project composed of five steps. The first two steps were focused on creating a rough model of the city map. In the initial step, students are tasked to discuss within their groups to come up with a set number of landmarks within the city that they wished to feature, and each landmark would be represented by a key that students come up with. For step two, the students were asked to plan a rough sketch of where to place such landmarks.

Step three asked students to figure out the dimensions of their map using a map scale and converting it to a given scale factor to find out the area of their town in square miles. A review of proportions was provided to help students refresh on the topic.

Step four prompted students to come up with a transit system and place twelve to fifteen transit stops around appropriate points in the city. As a supplement to the exercise, students were asked to identify six transit stops at various landmarks of their choice, and to provide a justification for doing so. Additionally, students were asked to find the distance between three pairs of landmarks that their city's population was most likely to travel to and from and were asked to whether the distance traveled was appropriate.

Step five concluded the project by asking the students to put together a final draft of their map.

Survey Overview

The project surveys were split into two sections addressing two purposes. The pre-project section inquired about student engagement and attitudes in math class. Those questions aimed to gauge factors such as their willingness to find creative approaches to problems, their work habits in completing assignments, their belief in what is the best skillset or method to excel in math, and their reception to the outreach of mathematics in terms of applications in real life and careers. It should be noted that as the students were not split into classes based on academic ability, the students were grouped into separate cohorts based on their initial interest in math class based on this portion of the survey.

In the latter portion of the survey post-project, students were asked for their feedback on the effectiveness of group learning experiences in the classroom. Some of the questions ask students whether they believe group work to be beneficial in providing adequate level of assistance from other students when learning and solving problems. In addition, the survey asked students whether they believe project-based learning to providing an experience that broadens student perspective during the problem-solving process. Overall, this section of the survey served as a means to gather students' receptions to the idea of project based learning alongside other classmates, in response to the "Fostering a Project-Based Learning Environment" section in Chapter 2, and assessing whether group project based learning can lead to a productive learning environment.

Based on the research above, the results of this study are then used to assess key claims such as:

- Students who viewed math class more favorably would be more willing to use a wider range of methods when solving problems.
- Students that emphasize practice and application of knowledge would view math class more favorably than those who resort to pre-disposed notions that students

are naturally gifted at math, or perhaps resorting to rote memorization as the key factor to success.

- Student work habits and work ethic are affected positively or negatively depending on their favorability of math class.
- Female students tended to have lower confidence regarding their preparation and confidence in tests compared to male students.
- Given the decline in confidence and efficacy for female students and considering the serious decline in student interest from sixth to seventh grade. Group work can be utilized to make the problem-solving process easier and allow students to benefit from such given that students are able to communicate with their peers, boosting student efficacy levels, while maintaining a reasonable level of confidence in math in the transition of sixth to seventh grades.
- Furthermore, group work produces positive results and boosts student efficacy levels within lower achieving students that struggle and do not view math class favorably.

Chapter 4 – Assessing the Results

Project Summary

The responses from the post-project survey were positive, with many students suggesting that the project provided a valuable opportunity for them to reinforce their knowledge on topics such as the coordinate planes, area, and perimeter. In the surveys issued after the completion of the project, numerous students had noted that fractions and conversion rates were topics that they had tended to struggle with, and that the project provided an appropriate means to review such topics. Overall, Mrs. Folsom noted that her students enjoyed the level of agency that they were given in the project, citing that it did not feel like a problem that came "straight from a textbook." Many students also thought the project to be thought-provoking in that it encouraged them to consider various aspects of a city in a mathematical context that they hadn't considered before.

As for group work, the results were a mixed bag. The student reception to group project-based learning in general was again mostly positive. Although many students tended to agree that working in groups provided additional perspectives that aided the problem-solving process, the common persistent issue was cooperation between students. This will be elaborated further in Chapter 5: Student Responses to Group Project Experiences.

Survey Results

While David Drew alludes to fifteen as the key age to consider in his quote, the students of this study that are between the ages of eleven to thirteen can still provide a vital perspective to consider, given that sixth grade is generally the first year when students are able to take supplementary STEM classes in math, science, and technology. The following are a series of questions that measure students' favorability, creativity, and work habits in math class, in addition to their perception on the outreach of math in general. The ensuing survey results are based on the following scale: 1-Strongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree, unless stated otherwise.

The results are split based on gender in order to identify any gender related trends or attitudes. Students were also given the choice to not answer should they not identify as either male or female, and the sections represented by a blank in the "Chose Not to Answer" portion indicates that there were no students who had chosen the aforementioned option.

General Attitudes

Cohort	A		B				C	
"I like math class."	**2**	**5**	**1**	**3**	**4**	**8**	**6**	**7**
Class Average	4.27	3.73	3.25	3.08	3.19	3.36	2.86	2.29
Boys	4.4	4	4	3.5	3.67	4	3	2.4
Girls	4.5	3.5	3.05	2.88	2.57	2.83	2.7	2
Chose Not to Answer	3.5	--	3.4	3.33	--	4	4	--

Figure 7: Average scores of students' general attitude towards math class, alongside gender data comparison

The first statement looks to gauge students' enjoyment of math class. Given that the eight sections are not split based on student ability, the other purpose of this question is to divide the eight groups into distinct cohorts for the remainder of the study. The student sections will be grouped into three cohorts based on the favorability rating of math class in each section, with

Cohort A containing the sections that viewed math class the most favorably, Cohort B consisting of the sections that viewed math class fairly favorably, and lastly, Cohort C as the section that viewed math class least favorably. The thresholds for the three cohorts were based on the gaps between the score ranges, with Cohort A between 4.27 to 3.73, Cohort B between 3.25 to 3.08, and Cohort C below 3.

Looking at the gender specific data, girls tended to enjoy math class less than boys across almost all sections, with the exception of Section 2, where the average score for girls narrowly edged the boys, although one could interpret this as a product of Section 2 being the highest scoring section in terms of class average rating. Nonetheless, this is a troubling indicator of the gender biases in math class which already fall in line with the points made by researchers above.

Cohort	A		B				C	
"Math has many applications in real life."	**2**	**5**	**1**	**3**	**4**	**8**	**6**	**7**
Class Average	4.36	4.4	4.18	4.62	3.94	4.18	3.93	3
Boys	4.5	4.5	4.71	5	4.11	4.5	4.67	3
Girls	4.4	4.29	4.21	4.63	3.71	3.83	3.6	3
Chose Not to Answer	4	--	3.4	4.33	--	5	5	--

Figure 8: Average scores of students' consideration for math and its real-life applications, alongside gender data comparison

The next statement looks to gauge student reception to the widespread applications of mathematics in their lives. Once again, the sections among Cohorts A and B are amongst the highest scoring, with Section 8 rebounding quite nicely in its score for this statement compared to the previous. Meanwhile, Section 4 was surprisingly the lowest scoring section amongst

Cohort B despite being the highest scoring section in the previous statement. For Cohort C, Section 6 scored quite well despite its low scores in the previous two statements, it is understandable that students can appreciate the applications of math in real life, but not necessarily view it to be most favorably. Meanwhile, Section 7 has been quite concerning given its low scores across the board thus far.

Looking further at the gender specific data, the boys scored very well again in this question, with every section scoring above a 4, except Section 7 which scored consistently a 3 throughout. Once again, the gender discrepancy is quite polarizing as girls did not outscore boys in any section for this question. However, it is at least promising to see that nearly all girls' scores have risen compared to their scores in Figure 7. Overall, the results suggest that the students still hold the importance of math in its application to a high regard, and students' enjoyment of math class is not necessarily related to students' view of math in terms of real-life applications.

Students were asked to briefly name a few real-life applications of math thereafter. Many of the students provided responses ranging from shopping, cooking, measurements, sports statistics, taxes, games, to various other forms of finances. This makes sense as the unit for decimals, fractions, and percents is usually introduced in sixth grade, thus their inclination to bring up finance demonstrates that they are making some of the real-life connections presented in their math classes.

There were other notable responses from students in Cohorts A and B which consisted of mentions for statistics, accounting, engineering, computer programming, chemistry, physics, and space sciences. On the contrary, the low scores for Section 7 on this statement coincided with the fact that the section that provide the least amount of mentions for higher mathematics by far. This is certainly concerning as one would hope that those students can be given more exposure or opportunities for STEM offerings to spark more interest in the matter. But all in all, it is encouraging to see that most students are well-aware and cognizant of the subject's applications in higher mathematics.

Cohort	A		B				C	
"I use different methods to solve problems."	**2**	**5**	**1**	**3**	**4**	**8**	**6**	**7**
Class Average	3.63	3.53	3.54	3.62	3.75	3.18	3.2	3.14
Boys	3.8	3.63	4	3	3.78	4	3	3
Girls	3.75	4	3.26	3.75	3.71	2.83	3.2	3.5
Chose Not to Answer	3	--	4.2	3.67	--	4	4	--

Figure 9: Average scores of students' willingness to apply different methods to solve math problems, alongside gender data comparison

This statement gauges students on their tendency to utilize different methods in solving math problems. The expectation is that the sections which saw math class more favorably would resort to using a variety of methods to approach and solve problems than the section which saw math class less favorably. The basis for this question comes from the findings of two British researchers Eddie M. Gray and David O. Tall in 1994. In their study, Gray and Tall observed young elementary school students and their approaches to solving problems. When given a rudimentary subtraction problem, the high achieving students substituted for equivalent numbers that were easier to solve in terms of mental math (changing 21-6 to 20-5), whereas the lower achieving students simply resorted to counting down from 21. With their thorough research of strategies used by students, Gray and Tall realized the factor which separated the low achieving students from the higher achieving was not necessarily due to having less knowledge, but rather being less flexible regarding problem solving. Those students would stick to the “formal procedures” that they had learned, but not having the intuition to turn to a plan B when the first attempt at solving the problem stagnates. Gray and Tall surmised that those students had perhaps been “set on the wrong pathway” early on, choosing only to memorize steps of the problem-solving process, and not reaping the rewards from actively interacting with the problems by formulating different approaches.

Looking at those results, it seems reasonable for the two cohorts that viewed math class more favorably would, for the most part, be more inclined to utilize different methods to solve math problems. As such, the scores throughout Sections 1 to 5 are quite consistent given the cohorts. However, it is rather curious that Section 8 is the outlier in Cohort B that deviated from the average of the three other sections within its cohort. On the other hand, Cohort C’s low scores with this statement seems to correlate with its score in Figure 7, as one could infer that students who do not view math class favorably are less willing to find different methods to solve math problems.

In terms of gender, there was an even split of sections that had either gender score higher which certainly differs from the trends that had favored the boys previously. One trend of note is that the girls of Cohort C managed to score higher than boys in both sections.

Lastly, an interesting angle to consider is even the classes that viewed math class more favorably had noticeably scored lower on a scale of 1-5 on this question than other questions with a similar scale. Perhaps this highlights the difficulty for many students at that age, when approaching math problems, to shift to a mindset that incorporate more of a number sense approach, rather than rote memorization.

Confidence in Terms of Gender

Students were asked to rate their confidence levels on a scale from 1-5 regarding their preparedness in math class, notably for stressful situations such as tests. The expectations heading into the survey were that boys would perform better than the girls, the students scored as follows:

Cohort	A		B				C	
Section	**2**	**5**	**1**	**3**	**4**	**8**	**6**	**7**
Boys	4.61	4.44	4.38	4.6	4.11	4.5	3.6	4.24
Girls	4.25	3.71	3.95	3.75	3.43	3.0	3.5	3.5

Figure 10: Average scores of students' confidence levels in terms of preparation for tests, sorted by gender

Given the results above, the gap between boys and girls in this area is confirmed to be true. Across the board, scores for the boys were consistently above 4, except for boys in Section 6 that scored a mere 0.1 higher than girls on average. Girls' scores were consistent as well in a similar fashion. Although it was not a surprise that the girls from Section 2 from Cohort A was the only section to score above a 4, given that Cohort A tended to view math the most favorably. The same can be said about the boys as Section 2 also scored highest on average. Overall, these results reaffirm that the difference in confidence between the two genders is still prevalent in the middle school setting. These results once again highlight the gender gap in terms of confidence and is surely a concerning factor contributing to the underrepresentation of women currently in the STEM workforce.

Best Mindset or Method to Excel

Students were then asked to select what they believe to be the best method or skill set for excelling in math class. The students selected one answer from the following choices: good memory, patience, natural ability, practice, paying attention, or other (Any students that selected Other were expected to specify their choice in a follow-up short response).

The specific choices chosen for this survey were based on the findings of Professor Jo Boaler of Stanford, alongside observations from Mrs. Laura Folsom in her teaching experience. On one hand, Boaler strongly advocates for practice and patience, while dismissing memorization as effective learning methods in math class. Likewise, Mrs. Folsom mentions attentiveness as another key method, while noting that students often will resort to the common misconception that natural ability is all that it takes to succeed in math class. Given those choices, the results are as follows.

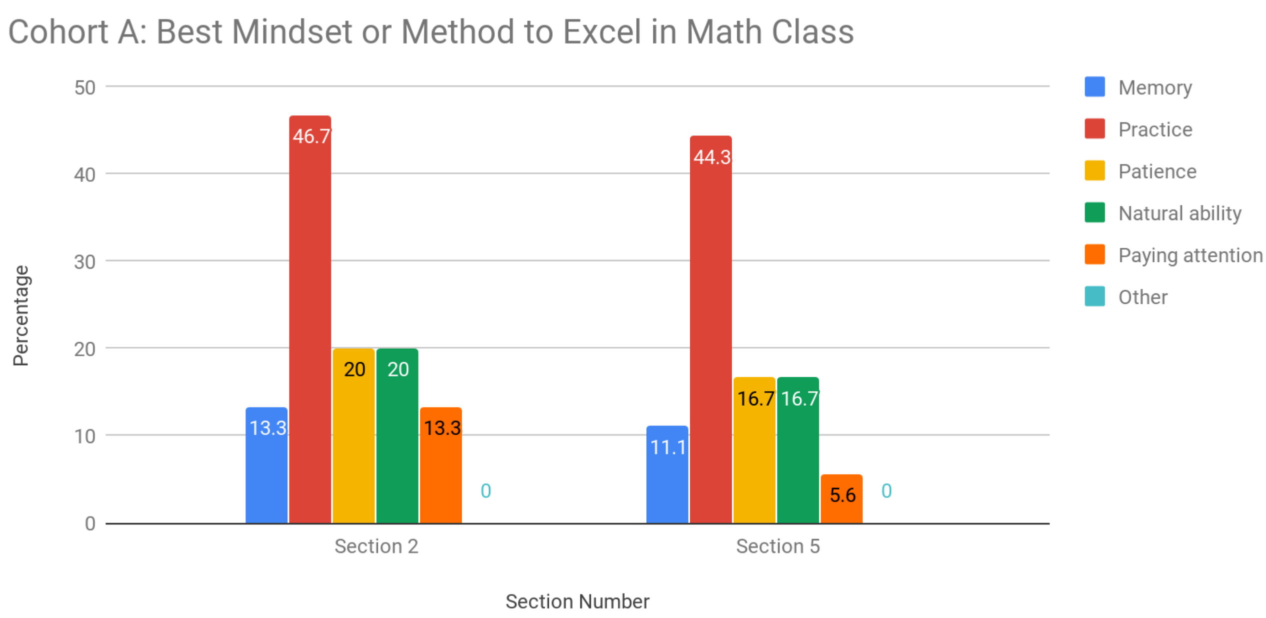

Figure 11: Student responses in Cohort A for mindset or method question

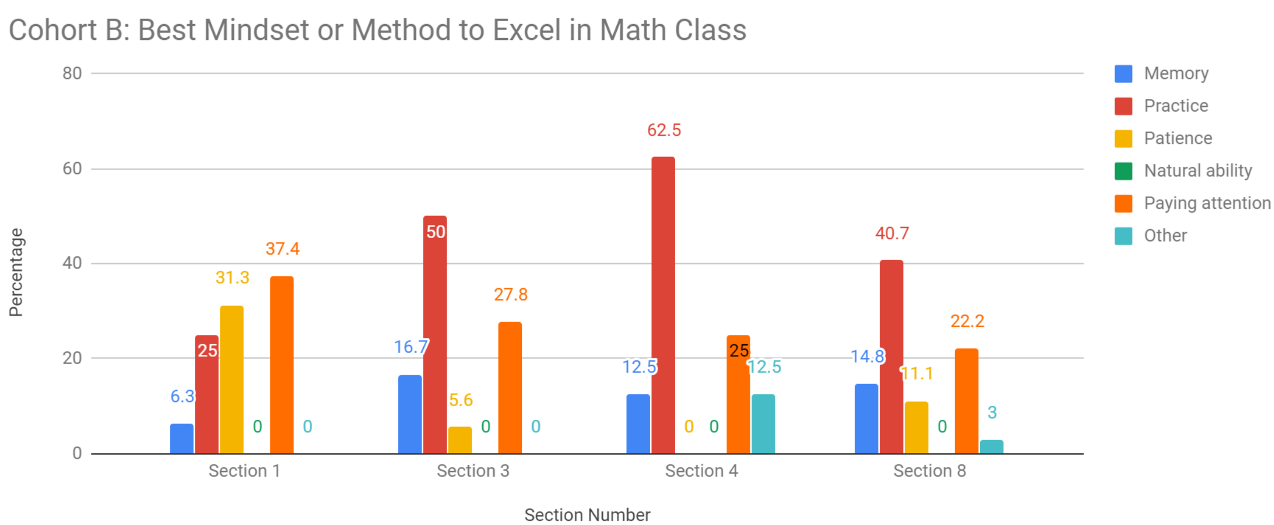

Figure 12: Student responses in Cohort B for mindset or method question

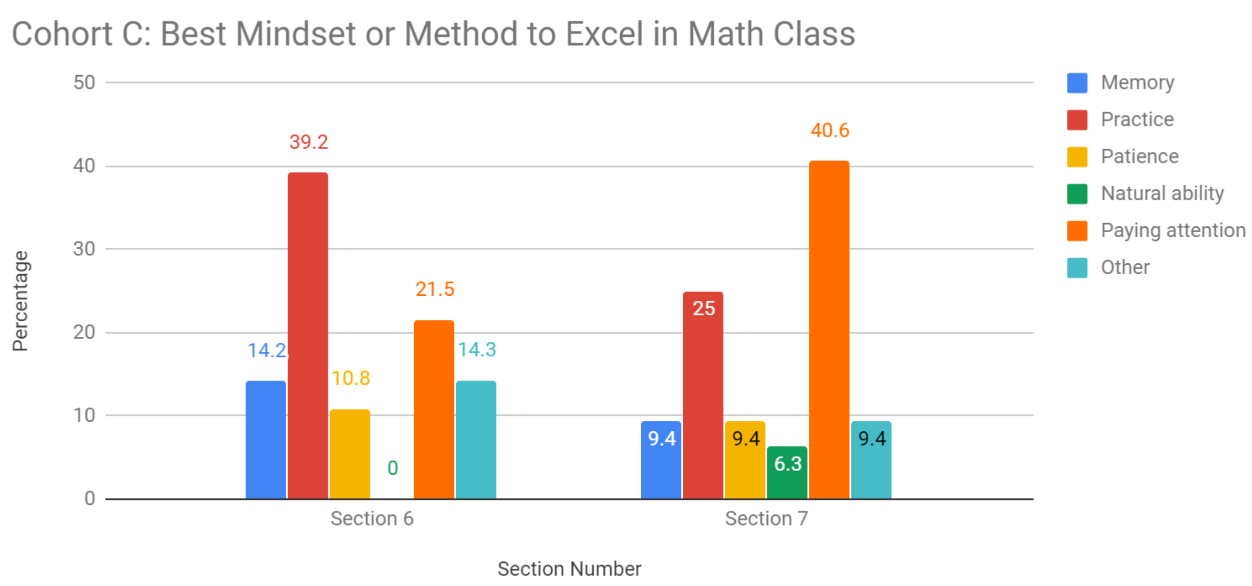

Figure 13: Student responses in Cohort C for mindset or method question

With those results in mind, there was a consistent pattern between the two sections of Cohort A. In context of Cohort A, it seems that students who see math class the most favorably are most likely to regard practice as the most common mindset needed to excel in math class, with patience coming in at second. There was a similar distribution of students that responded with having a good memory, and a disparity with a 15% difference between the two sections considering paying attention as the most important.

In Cohort B, for the most part its sections had responded with practice as the most popular skillset, alongside similar distributions in choices such as memory and paying attention, except for Section 1, which had paying attention as the most important.

For Cohort C, the results were not nearly as similar as the previous two cohorts. There is a stark contrast between the two classes, with practice at 39.2% is the most common response in Section 6, whereas paying attention makes up for a similar percentage at 40.6% in Section 7.

The students then provided responses to elaborate further on their choices. For many students that favored practice, the main argument was simply “Practice makes perfect,” that having the valuable experience in navigating through many problems is the primary factor for excelling in math. The arguments for patience were reasonable, as those students believed that taking the time to analyze problems, especially those that are lengthy, are crucial in maintaining, to paraphrase, a measured approach to get the results needed. Some students also mentioned persistence as a similar means to work through challenging problems.

As an aside, there was a consistent 6-14% of students in Cohorts A and B that responded with memory. Looking at their responses, the main arguments suggested that having a good memory was beneficial in retaining the material learned from class. Given the reputation that math may have at times for being overly dependent on memorizing formulas and solutions steps, the choice of memory did not exceed 17% in any classes and was at best, the third most popular answer in all classes. This seems to indicate that while the stigma of math being a memorization heavy subject can exist to some small extent, more students are willing to see past it for approaches that involve putting in the effort in working out the problems, whether it is via practice, paying attention, or simply being patient.

Looking further at the responses, students from Section 7 suggested that paying attention was crucial in picking up the information presented in class, after all, being observant is the first step to understanding. This was also supported by students of Section 1. While this is certainly an acceptable answer, there was another response from Section 6 which suggested practice to be the best method. The student argued that, to paraphrase, paying attention is only secondary to practice. The student did not articulate further on why paying attention is secondary, however reading in between the lines, it seems perhaps the student was trying to infer that practice is the step that makes use of the material learned by paying attention, but ultimately, putting in the repetitions confirms a student was in fact, paying attention.

The miscellaneous responses in "Other" proved to be quite constructive as well. One student noted focus and concentration as key underlying factors that should be acknowledged in maintaining many of the aforementioned methods or mindsets. The most common answer provided was confidence, especially so for students in Cohort C. Recalling Bandura's definition of confidence, which is "self-assurance resulting from a belief in one's own ability to achieve things," and his belief that self-confidence plays a major psychological role that influences student performance, it seems apparent that confidence is appropriately significant as a mental factor for students of Cohort C in order to maintain their levels of engagement in math class.

Overall, this statement provided quite a constructive debate in between the choices provided, and it is promising to see that many students are cognizant of the levels of effort and commitment needed to excel in math class.

Work Habits

Students were then asked to evaluate their work habits in relation to completing math assignments, with the following choices:

"I get it done as early as I can, so I don't have to deal with it later,"

"I like to spread out the work evenly over a period of time,"

"I do it the day before it's due/I'm up all night,"

"I don't care for due dates."

The ensuing question then aims to confirm whether students that viewed math more favorably would tend to have better work habits when completing assignments, thus forming a good work ethic when it comes to math class.

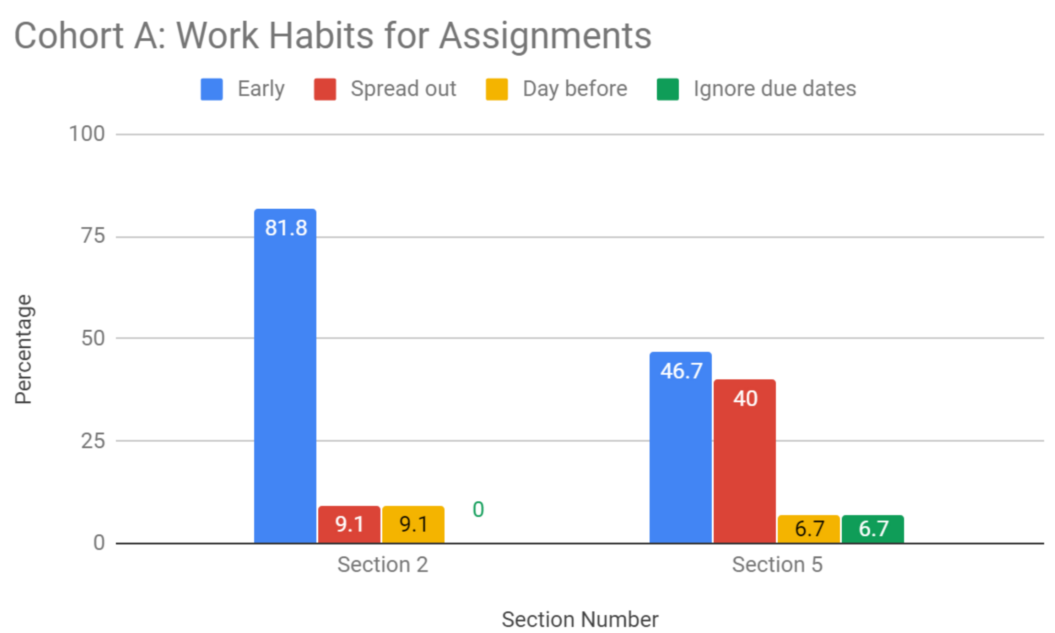

Figure 14: Work habits of students in Cohort A regarding assignments

Looking at the results for Cohort A, it seems quite reasonable that most students who enjoy math class are generally the ones that form good habits for assignment completion. Those students demonstrate their good work ethic by either giving themselves enough time to spread out the work over multiple days or completing the work ahead of time. Likewise, given the enthusiasm from Section 2 for math class in Figure 7, it logically follows that the students of Section 2 would have the highest percentage of students that tend to finish their work early amongst all classes in all three cohorts.

Meanwhile, there was a larger percentage of students in Section 5 that preferred to spread out their work evenly, and inversely a much smaller portion that finished their assignments early. While spreading work out evenly is not a habit that is of concern in and of itself, it is rather curious to see such a significant discrepancy. Thus, students were asked in a later follow-up question to rate on a scale of 1-5, about whether they had given themselves enough time to complete assignments after school daily.

Section	2	5
Avg. Score	4.13	3.39

Figure 15: Students in Cohort A are asked to rate on a scale of 1 (I don't give myself much time) to 5 (I give myself more than enough time) regarding time spent on assignments.

The results clearly showed that students' choice in allotting enough time after school to complete assignments can play a factor between completing work ahead of time or completing work spread out to multiple days.

All in all, given that both sections had attributed practice as the best tendency for excelling in math, it is encouraging to see that both sections are forming good work habits in realizing that tendency.

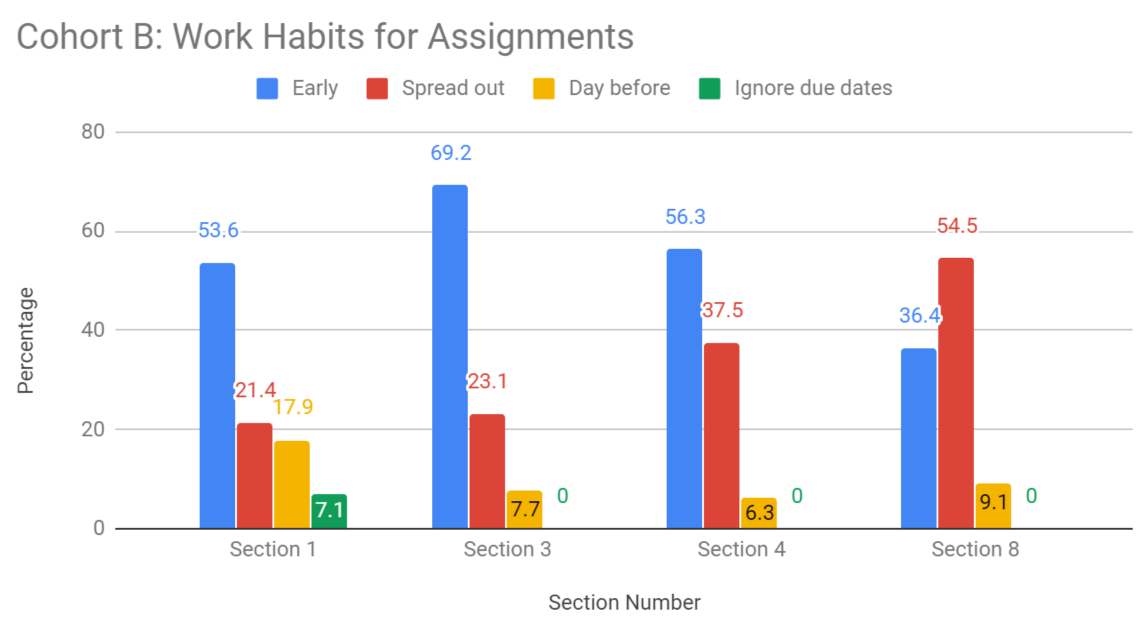

Figure 16: Student work habits with assignments in Cohort B

Looking at the results of Cohort B, Section 1 seems to be the outlier within the cohort that had a small representation that chose to ignore due dates, as well as seeing a 9% increase from the next closest section in students that preferred to finish work the day before. Although a 17.9% of students that finish their work the day before is not necessarily alarming, it does make sense in context of the follow-up question about time, with its results shown in Figure 16, as students in Section 1 scored the lowest by far amongst Cohort B in regards to giving themselves enough time after school to complete assignments. It is also interesting to note that Section 1 was by far the section that had the lowest combined percentage of students that finished work early or preferred to spread work out, at exactly 75%, with the next closest section at 86.7%. Recalling the results from Figure 12, Section 1 had practice as the third most popular choice, and the smaller emphasis on putting in the time to practice can perhaps carry over to those students' work habits.

On the other hand, the highest portion of students that tend to finish their work early in Sections 3 and 4 is likewise the two sections that scored the highest in the follow-up question about giving themselves enough time after school to complete the assignments.

Section	1	3	4	8
Avg. Score	3.25	3.78	3.86	3.67

Figure 17: Students in Cohort B are asked to rate on a scale of 1 (I don't give myself much time) to 5 (I give myself more than enough time) for time spent on assignments

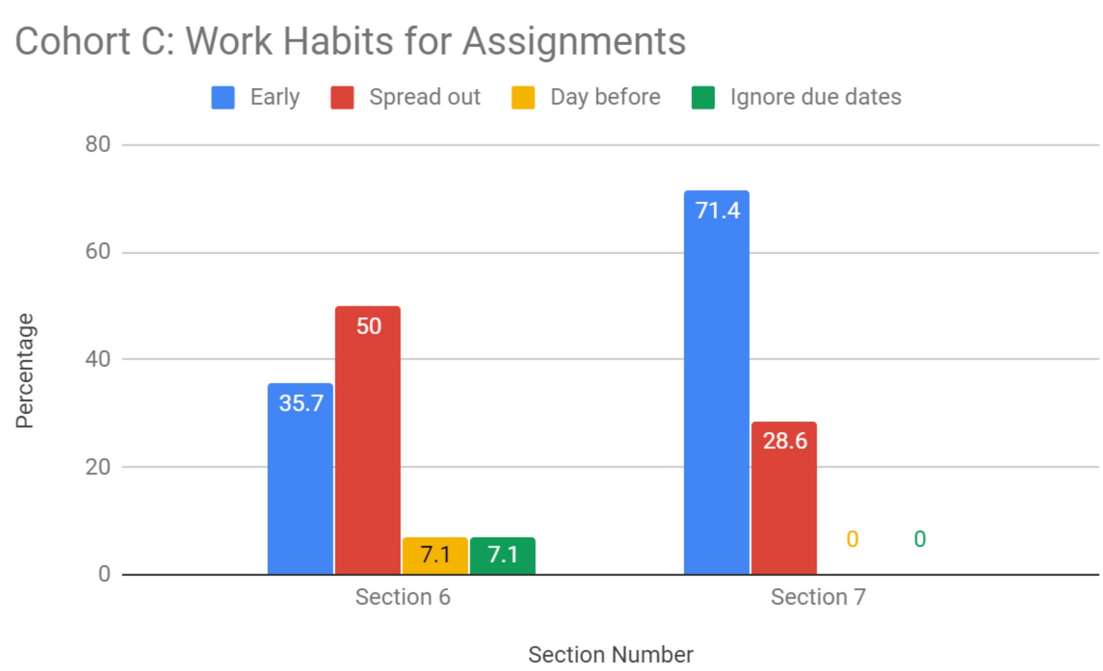

Figure 18: Work habits of students in Cohort C regarding assignments

Lastly, Cohort C scored rather well in this category given its lower scores in the previous survey statements, which was reassuring to see. This is especially the case for Section 7, in which its students seemed rather intent on completing their assignments early. With the follow-up question about time in mind, it follows that the lack of students preferring to finish work the day before, or ignoring due dates altogether in Section 7, would score higher than Section 6 when it comes to giving themselves enough time after school.

Section	6	7
Avg. Score	3.57	3.94

Figure 19: Students in Cohort C are asked to rate on a scale of 1 (I don't give myself much time) to 5 (I give myself more than enough time) for time spent on assignments

Overall, given the lack of a strong pattern between work ethic of cohorts being higher depending on the section's favorability of math class seems to suggest that the work ethic for many students surveyed is formed independent of math class. On that note, it is encouraging to see that those who did not care for deadlines proved to be a very small minority amongst all the sections. Seeing that no section had eclipsed a combined 20% for students that did their work either the day before or ignoring deadlines altogether, it reflects well upon the sixth grade students of P. Trottier Middle School, that many of them are not only willing to put in the effort with practice, but also forming good habits while putting in the effort to complete assignments on time.

Future Aspirations

To conclude the first half of the survey, students were asked about their interest in pursuing a mathematics related career in the future. Students were given the choice to select "yes", "no", or "not sure", in addition to answering an optional follow-up response if they wished to elaborate.

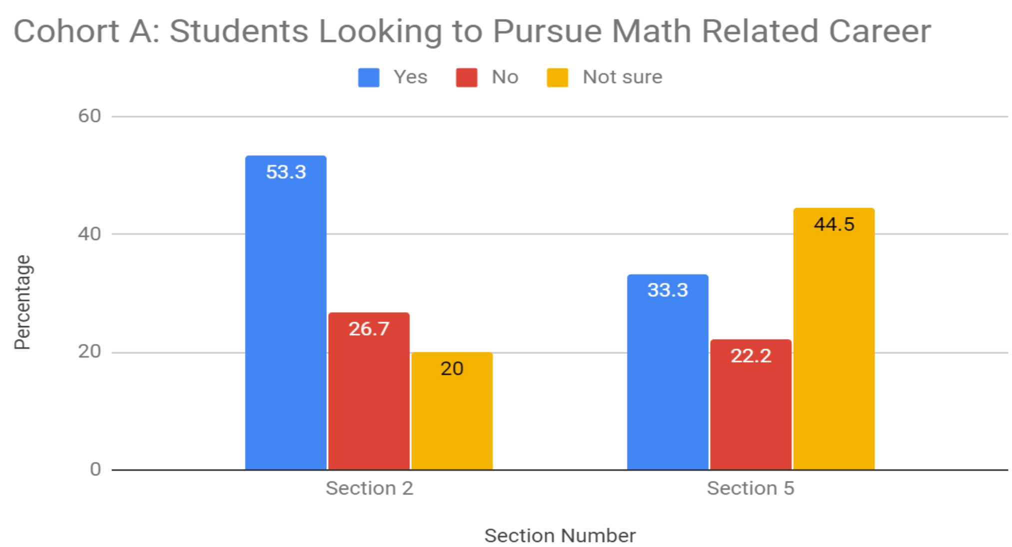

Figure 20: Students of Cohort A are asked about whether they are interested in pursuing a mathematics-related career in their future.

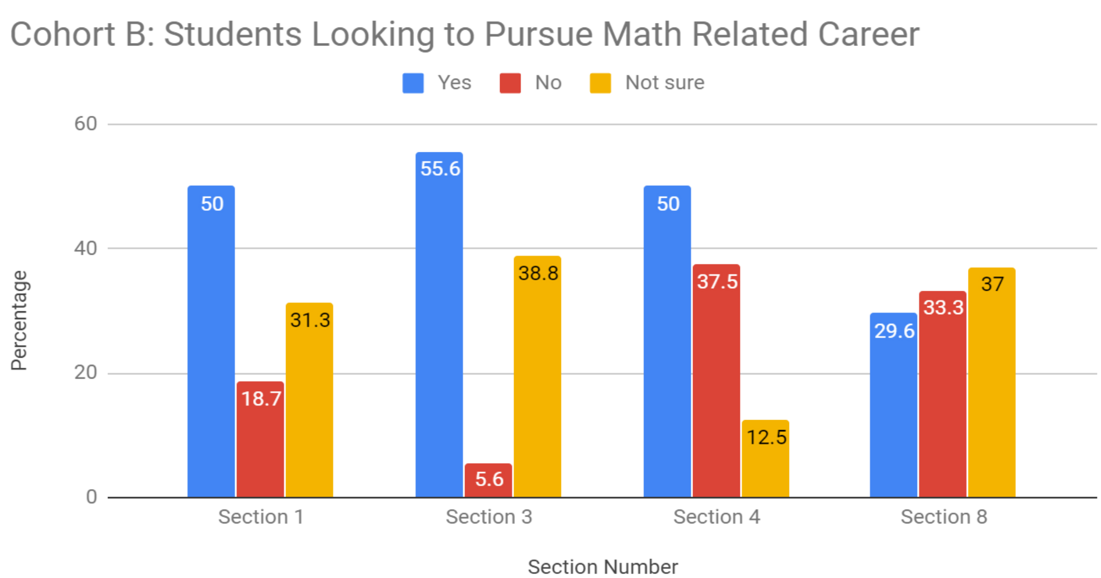

Figure 21: Students of Cohort B are asked about whether they are interested in pursuing a mathematics-related career in their future.

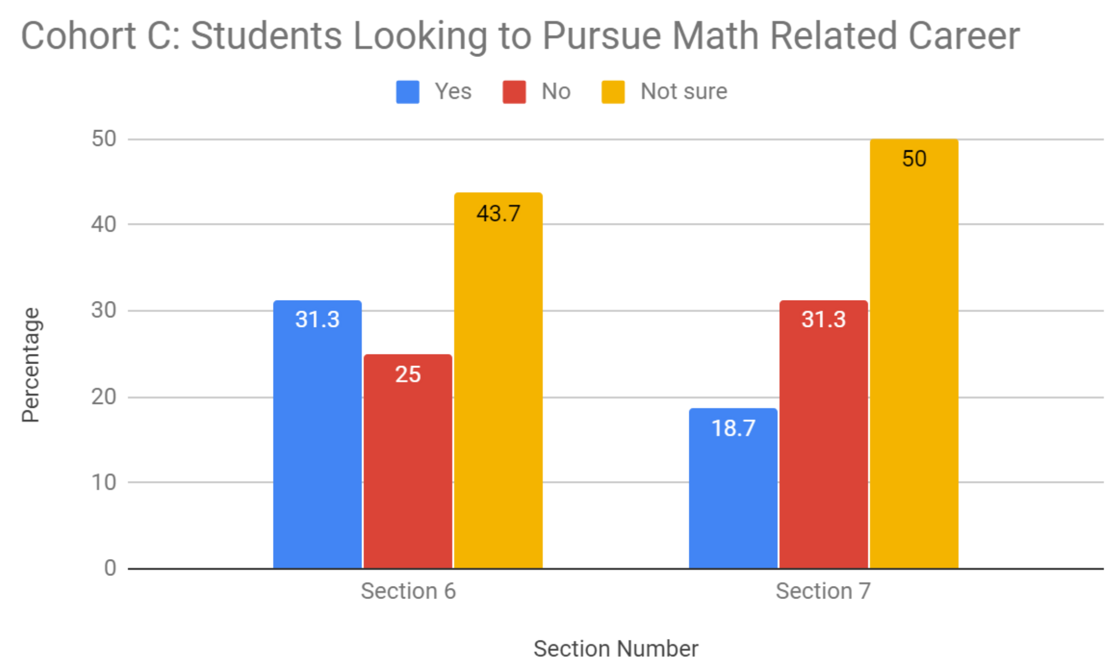

Figure 22: Students of Cohort C are asked about whether they are interested in pursuing a mathematics-related career in their future.

The results for those that were interested in pursuing a career in math were consistent amongst Sections 1 to 4, scoring in the range between 50-56% for yes and only one section that scored slightly higher than 25% for no. To reiterate from responses provided in an earlier question about applications in math, the results from Sections 1 to 4 are quite consistent in that those were the same sections which mentioned the higher-level mathematical fields the most. Altogether, this reflects well on the students that have the ambition to see themselves working in the mathematical fields.

In context with the previous question on work habits, Sections 5 and 8 scoring the lowest for yes mirrors its scores in regarding to work habits, where those two sections were also the only sections in Cohorts A and B that had scored below 50% for completing assignments early.

With that in mind, one could infer that being less inclined to finish assignments early could perhaps impact a student's enthusiasm for pursuing a mathematical related career. However, the students in Cohorts A and B that were indeed looking to pursue a mathematically related career mentioned professions in fields such as biology, research, teaching, and one student even mentioned his or her goal of becoming a statistician. All in all, it was still promising to see that the professions mentioned are consistent with the professions brought up in the prior question about the real-life applications of math.

It was evident that the students of Cohort C were amongst the lowest percentages in answering yes to pursuing a future career in math, while making up for the highest percentage of students that were unsure of such potential career choice amongst all sections. Furthermore, Section 7 was the by far the section with the lowest percentage for yes to a math related career at a measly 18.7%, and that is quite consistent with the other poor scores that Section 7 provided throughout the study. Looking at the responses provided in the follow-up question for Sections 6, 7, and 8, some students outright stated that they did not enjoy math class and, to paraphrase, did not see themselves pursuing math further than what is required of them in school.

Looking further at the responses provided, for the students that answered not sure in Cohorts A and B, there were general concerns for their ability to keep up with the level of content taught in higher math. Their fears are reasonable, as one could expect that while students may still see math class favorably at the sixth-grade level, the rise in difficulty in the material presented in the upcoming grade levels can potentially sway student opinions in the other direction. This is supported by the findings of Eccles's research group, as they had discovered that there was a significant decline in students' confidence and self-esteem levels in the transition from sixth to seventh grade.

However, the most common concern was being unsure of what career the students would pursue in general. Some of the students were quick to point out their young age (mostly eleven or twelve) as a reason for not being ready in picking a career choice. These remarks are essential to keep in mind moving forward in context of David Drew's quote. Despite Drew's notion that it takes fifteen years to raise a scientist or engineer, it is clear that these students, while approaching the age of fifteen, yet are still dealing with personal factors such as confidence, as well as readiness in terms of pursuing higher level math for school and career choices.

Chapter 5 - Student Responses to Group Project Experiences

In the second half of the survey, students were asked for their feedback on their experiences working alongside classmates for the project, as well as their attitude towards group-based work in general. The feedback to the following series of questions and statements looks to establish whether group work can be an effective method in the classroom to boost the productivity, self-efficacy levels of lower achieving students.

Cohort	A		B				C	
Question/Section	2	5	1	3	4	8	6	7
"I am productive during group work."	4	3.93	4.25	4.23	3.75	3.54	3.57	4.29

Figure 23: Students are asked to rate their levels of productivity during group work.

The initial statement asked students to rate their levels of productivity during group work, and students were asked to rate on a scale of 1 to 5, with 1 as "Not productive at all" and 5 as "Very productive." The results for Cohort A are in line with the results above and suggests that the two classes which enjoy math class the most would also be productive during group work. However, the scores in Cohort B were more polarizing, as Cohort B consisted of two of the highest scoring sections in combination with two of the three lowest scoring sections. Looking at the short responses, there was a common complaint of not getting along with other classmates, as well as struggling with dividing responsibilities during group work. Such responses were more common in Sections 4 and 8 given their lower scores to the question above.

However, the biggest takeaway from this statement is the high scores from Section 7, given its low scores across the board from many of the previous questions, one could perhaps see group work as a potential avenue to explore in increasing student productivity for classes that may show a lesser interest in math.

Cohort	A		B				C	
Question/Section	2	5	1	3	4	8	6	7
"When I didn't understand something in the group project, my group was able to help me understand."	3.81	3.6	3.71	3.54	3.69	3.27	3.57	3
"Working alongside other students in groups made the problem-solving process easier."	3.55	3.4	3.79	3.92	3.88	3.54	3.57	3.14

Figure 24: Students are asked to rate whether their group members were able to help them understand, and in making the problem-solving process easier during group work.

The two statements above gauges whether students can seek help from their fellow classmates when facing challenging concepts, as well as whether seeking such help made the problem-solving process easier. The interesting trends to see here are that scores tended to improve from the first statement to the second statement for classes in Cohorts B and C, while the scores in the second statement declined from the first statement for Cohort A.

The scores in Cohort A initially are quite surprising. When looking at the individual responses, many students in Cohort A had felt that they were knowledgeable enough to prefer tackling the problems on their own for the most part. While there will be questions that will entice those students to seek help from others in the group, students may simply be interpreting "Working alongside other students in groups made the problem-solving process easier" for all types of questions, which includes the questions that they feel confident enough about without the assistance of others, thus the slightly lower score with the aforementioned statement makes sense. Then for Cohorts B and C, the improvements in scores were encouraging to see and indicates that working with others does make a difference in the problem-solving process.

The other point of interest to note here is that Section 7 was once again the lowest scoring section despite scoring the highest in Figure 23 for individual productivity. It seems that student cooperation is the key culprit here, which indicates that cooperation is the key obstacle to overcome to maintain productivity. But considering the general positive reception that those students have towards group work, it is important for a teacher to not dismiss group work as an option for those students, but rather help those students foster a productive environment for group work that leads to better cooperation. In doing so, there are approaches teachers may try, such as giving set responsibilities to students to ensure structure within groups. As an aspiring educator, it seems that such classes will require the most effort in terms of fostering positive work ethic and relationships between students, nevertheless it can be the most rewarding if one is successful in fostering a productive learning environment.

Cohort	A		B				C	
Question/Section	2	5	1	3	4	8	6	7
"Group projects are helpful because it allows me to see from different perspectives through working with others."	3.81	3.6	3.82	3.62	3.69	3.63	3.71	3.29

Figure 25: Students are asked about perspective in terms of group work

The results from this question were quite consistent across the board, with almost all the classes agreeing that group projects can offer the benefit of seeing a problem through a wide range of perspectives. Overall, it seems that students were far more positive towards this question, as seeing different perspectives can take on a greater precedent than making the problem-solving process easier. It is reasonable to think that while a group might struggle to solve a problem, the experience of seeing different creative approaches despite those struggles can broaden a student's arsenal for solving problems in the future.

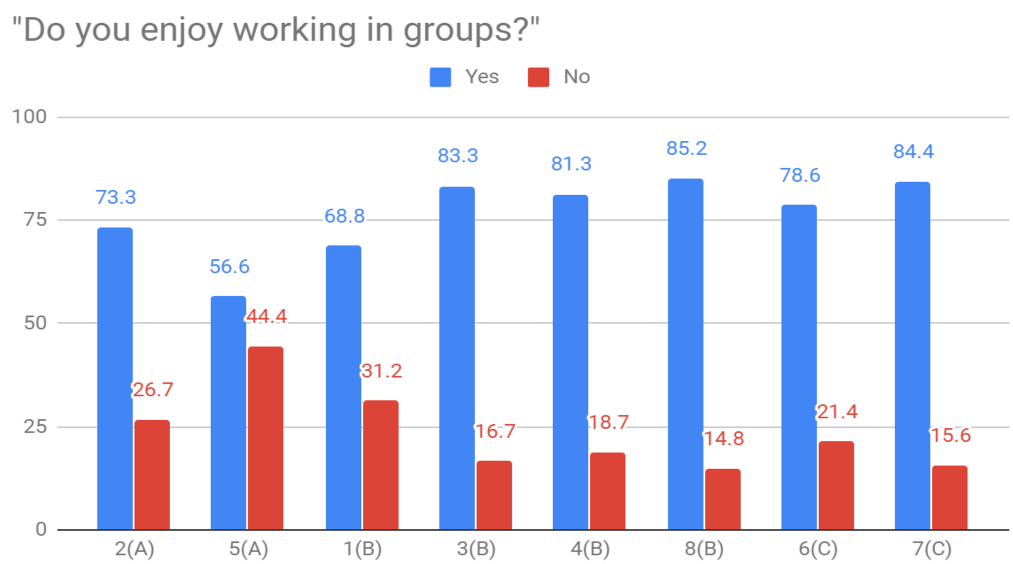

Figure 26: Student reception to group work

Finally, students were asked to if they enjoyed working in groups in general and the results were for the most part, very positive. It was fascinating that Cohort C were amongst the sections that answered above 75% for yes to the question, despite issues about cooperation and handling of responsibilities. This seems to indicate that group work can remain a viable approach for lessons in classes like those in Cohort C, as students will still react quite positively to getting opportunities for group work. Now of course, it is then up to the teacher to find ways to maintain student productivity, giving students well-defined roles within their groups, while keeping a closer eye on disruptive behavior to ensure that group work can provide a productive environment. The same applies to classes such as Cohort B, as doing such can only boost the student experiences with group work further.

On the other hand, students in Section 5 were much less enthusiastic to group work compared to other sections. This makes sense within Cohort A given that Section 5 had scored lower than Section 2 through Figures 23-26. It certainly seems that the students of Section 5 may be comfortable with independent individual work instead. With that in mind, a potential approach for teachers to consider is to issue more material that is appropriately challenging to those students, encouraging them to tackle such problems as a group rather than as an individual to give students more opportunities to work well with each another. To reiterate the research done by Strobel & van Barneveld (2009), there are many more benefits in establishing a positive collaborative environment between students in terms of retention and communication skills.

Given the responses from the section of the survey above, one could certainly see that group-based work has potential in further developing a productive work environment for many students. While it is not without its obstacles in terms of student maturity and responsibilities, there are benefits in group-based work that can improve student communication skills between their peers. Given the potential of such benefits, is then up to the teacher to help foster a learning environment that encourages better student engagement within groups.

Chapter 6 - Teacher's Perspective

At the conclusion of the project, Mrs. Folsom shared her perspective on her students' attitudes towards math as a subject in general, while providing her perspective on a few other questions presented throughout this study.

When asked about the best mindset to have for excelling in math class. Folsom agrees with the emphasis on practice, as she makes a metaphor to swimming. A student can simply pay attention and observe a swimmer, but that student will not know how to swim until he or she goes into the water. In other words, practice is the appropriate follow-up to the idea of observing, to confirm that a child is in fact, able to know how to do the task at hand after observing.

Folsom also makes the case that curiosity should be the best mindset for excelling in math, she mentions that it is the curiosity to explore the unknown in math, even if it may lead to failure, is the driving factor that helps students improve at math. One of Folsom's notable lessons plans was on a day that she had taught the Triangle Inequality Rule to her classes, and to quote her, the students were "glassy-eyed" from watching her lecture on the board, but did not feel entirely confident on applying the topic on their own. Thus, Folsom extended to lesson by giving her students popsicle sticks to work with and to come up with triangles of their own of various dimensions. When the students failed at making triangles with valid dimensions, they were able to see first-hand why their triangles were incorrect. Therefore, learning through such mistakes and failures provided a valuable lesson, while giving students insight on what they could have done correctly instead. Folsom certainly advocates for giving students more opportunities to work in groups, as she believes that it is crucial to give students an early glimpse into how jobs in our industry often require group work.

When asked about the biggest obstacles that students face in learning, Folsom suggests that mental blocks are often the main factor that holds students back. This seems to go hand in hand with what some students had suggested in the survey above, where confidence is an essential factor to have to approach math with a healthy mindset. Furthermore, these mental blocks can become biases and stereotypes that students struggle to overcome, such as girls and minority students being told that they don't have what it takes to succeed in a STEM-related subject. Folsom believes that providing plenty of opportunity for students to practice the topics they learn can help solve this issue. In doing so, raising the level of confidence that students need to overcome their mental blocks. It certainly seems that Laura would support her students' position on practice as a key method for excelling in math class.

Folsom disagrees with David Drew's referred quote that, "It takes fifteen years to raise a scientist." She firmly believes that learning is a lifelong process, and that applying arbitrary limits in forms of age will only hinder our progress in our path of learning.

Chapter 7 - Conclusion

As an aspiring educator, the project was productive in having an opportunity to collaborate with a teacher and her students to create a project-based set of lessons in a STEM classroom setting. While the entirety of the lesson materials was not fully implemented, the part that was implemented served as a good source of review and reinforcement for the students. Furthermore, there was an additional challenge in creating lessons that were appropriate to grade level, while finding middle ground in working alongside an experienced teacher to accommodate for her own busy schedule. In doing so, one realizes the daily challenges teachers face in presenting material in class in an effective, yet efficient manner.

Looking at the surveys, the data provided valuable insight and confirmed trends that one would expect from a middle school setting. While the sections were grouped into cohorts based on their favorability rating of math class, for the most part, the sixth-grade students of P. Trottier Middle School reacted quite positively to the idea that math has quite a lot of valuable applications outside of the classroom. The students who enjoy math class tended to score higher in their willingness to use a wider variety of approaches in the problem-solving process, this is beneficial to their number sense skills, as the diversified approaches will help students improve their number sense flexibility when solving problems.

The students also shared constructive insights on the mindsets and or methods needed to excel in math, as many students embraced approaches that required them to put in a great deal of effort in terms of practice, paying attention, and patience. This is reflected in many students having the work ethic in completing their assignments in a timely manner.

At the same time, there are still concerns amongst students in terms of their readiness for the ever-increasing difficulty of the material taught in class. This is in line with the research which showed that student confidence in STEM related courses tended to decline starting from the latter months of sixth grade, heading into seventh grade. As a result, quite a lot of students were not entirely confident that they are able to keep up with content taught later in their academic careers.

With that in mind, it has been shown that confidence can be quite a significant psychological factor that influences student performance in the classroom. When asked about their confidence in test preparation and in math class in general, female students performed worse than males in every section. The confidence gap between male and female students demonstrates the reason for the gender discrepancies in the STEM workforce currently.

Looking at potential solutions to address the lack of confidence, one can look to group work and project experiences as an avenue that benefits students. In group work, students are given opportunities to consult with their peers, thus increasing efficacy levels in their classes Furthermore, giving students more exposure to group work can allow students to share perspectives, as well as to reduce how intimidating STEM careers may be for some students, given the group work focused natures of some STEM jobs.

Meanwhile, the study confirmed issues such as maturity and the handling of responsibilities amongst the students as the biggest culprits that hindered the group project learning experience. However, many students still regarded such experiences as productive. Furthermore, those students considered the group project-based learning aspect to be beneficial to the problem-solving process, as well as providing valuable, alternative perspectives. Overall, it can be said that the benefits outweigh the concerns, if a teacher is able to maintain a productive and respectful environment between a student and his or her peers. Moreover, fostering such an environment for learning can give students the experience one needs for those that wish to pursue a mathematically focused, or in general, STEM-focused career in the future that will most likely include group work experience as well.

Revisiting author David Drew's quote that, "It takes fifteen years to raise a scientist," with the new perspectives offered from the students as well as Laura Folsom, it does seem that fifteen perhaps may still be too early of an age that Drew had set for students. In that case, perhaps the focus should not be on an arbitrary age limit in regards to our expectations for our students, but rather maintaining open-minded approaches that encourages better engagement, while inspiring more confidence within our students so that they can pursue the careers they wish to pursue without any doubts. This is the great responsibility that many educators should and will look to fulfill for this and many generations to come.

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Appendix A: Project Description

Mapping a City Challenge

Names:_______________________ **Date:___________** **Section:___________**

Challenge

In this challenge, you and your group (of 4 or 5) are tasked to mapping a whole new city. Your goal is to create a map that closely reflects the landmarks you would expect to see in a real-life city. In addition, you and your group are also tasked with creating a transit system that traverses through the city to complete the challenge.

Rules

Make sure you fulfill all the requirements given, keep everything on the grid.
Other than that, have fun… be creative with your map!

Step 1 - Landmarks/Buildings

Landmarks/buildings are often the main features within a city. Come up with 29 more landmarks to complete this step. Try to come up with a symbol for each landmark you put on your map. Here are some examples to start you off...

Post Office 	School	Library			

Step 2 - Rough Sketch (Plan out a rough sketch of where you may place your landmarks here, don't worry about any measurements or scaling yet. Your symbols might come in handy here, and you might want to keep this paper around for the next day!)

Step 3 - Map Scale

Unit Conversions/Scaling Mini-Review:

For example:

12 inches ÷ ___ = 1 feet

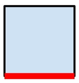
1 feet x ___ = 12 inches

If 1 feet = 12 inches, then…

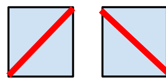
x3 x___

3 feet = ___ inches?

The scale factor is:



1 block = .1 mile



Any diagonal is about 1.5 blocks = .15 miles

3 .0 blocks = ____ miles?

1 mile = ____ blocks?

TIP: *See a pattern with the decimal? What direction does the decimal move in when you go from blocks to miles? Miles to blocks? How many places?*

Approximate the total area of your city:

The formula for area is: ____________

Area = ___________

HINT: If you map doesn't cover the entire grid evenly, break it up into pieces and find the area of each 'piece', then add it up!

Step 4 - Transit System

Go back to your rough sketch from Step 2...

Create anywhere from 12-15 transit stops around your city. Feel free to use the symbol below or a symbol of your choice. Just make sure it is easily distinguished!

Be aware of your placements!

For example, you may want to put a transit stop at a mall, or school...think of other landmarks that are more convenient to travel to on transit. Identify 6 landmarks of your choice, and briefly jot down why you believe a transit stop is needed for it.

1.

2.

3.

4.

5.

6.

Additional Challenge:

Find the distance between the 3 pairs of landmarks that people are most likely to travel to and from. Do the distances make sense?

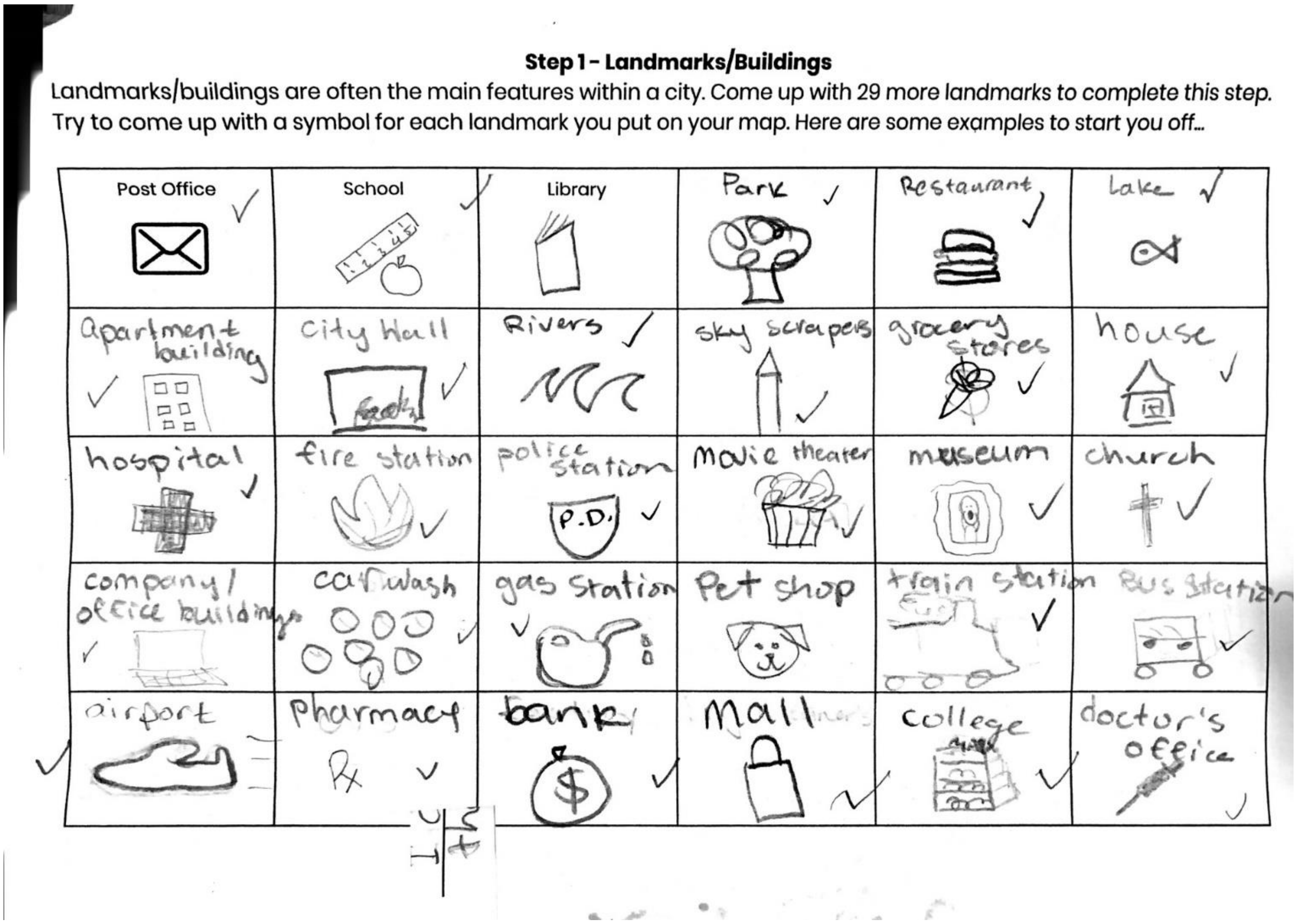
HINT: Write down the coordinates (x,y) for each pair.

Convert the value represented by ‘d’ to miles.

Step 5 - Putting it all together

Once you’re all done with the rough sketch, finalize it on Google Drawings!

Appendix B: Student Work



Step 1 - Landmarks/Buildings

Landmarks/buildings are often the main features within a city. Come up with 29 more landmarks to complete this step. Try to come up with a symbol for each landmark you put on your map. Here are some examples to start you off...

Post Office	School	Library	Park	Restaurant	Lake
apartment building	City Hall	Rivers	sky scrapers	grocery stores	house
hospital	fire station	police station	Movie theater	museum	church
company/ office buildings	car wash	gas Station	Pet shop	train station	Bus Station
airport	Pharmacy	bank	Mall	college	doctor's office

Step 2 - Rough Sketch (Plan out a rough sketch of where you may place your landmarks here, don't worry about any measurements or scaling yet. Your symbols might come in handy here, and you might want to keep this paper around for the next day!)

Link to a 12x8 (inches) grid to potentially use?:
https://docs.google.com/drawings/d/1dL-RGxIzcsDB7w8NVsrXvNpwARXY6Za-Tbqgesnr6VM/edit?usp=sharing

Step 3 - Map Scale

Unit Conversions/Scaling Mini-Review:

For example:

12 inches ÷ ___ = 1 feet

1 feet x ___ = 12 inches

If 1 feet = 12 inches, then...

x3 x___

3 feet = ___ inches?

The scale factor is:

1 block = .1 mile

Any diagonal is about 1.5 blocks = .15 miles

3.0 blocks = .3 miles?

1 mile = 10 blocks?

3.2
× 2.6
192
640
8.32

TIP: *See a pattern with the decimal? What direction does the decimal move in when you go from blocks to miles? Miles to blocks? How many places?*

Approximate the total area of your city:

The formula for area is: l x W

Area = 8.32 units^2 *(what unit do we use for area?)*

HINT: *If you map doesn't cover the entire grid evenly, break it up into pieces and find the area of each 'piece', then add it up!*

6th grade Tech Ed
MAP project
Distance calculator Worksheet (Math- hooray!!!)

Now that your map is complete, you are going to calculate the distance between points on your coordinate plane. Remember that coordinate points are always in alphabetical order (x,y), where x = the coordinate on the x axis (horizontal axis - remember the sun comes up on the horizon) and y = the coordinate on the y axis (vertical axis, because I always make my "y" with a really long tail so I remember that the y axis goes up and down).

1) Start out at a house or neighborhood on your map. What did you pick? Park
2) Record the coordinates of your location here: (x = 0.6, y = 0.5)
3) Pick a fun place to go, perhaps a favorite store. Where will you go? mall
4) Record the coordinates of your destination here: (x = 1.8, y = 1.0)
5) Now count the distance that you would have to go to get from one to another. Record that information here: 17 (1.7 miles) blocks
6) Here is the fun part: go (online) to here: https://www.mathportal.org/calculators/analytic-geometry/distance-and-midpoint-calculator.php
7) Enter your coordinates of your starting point (same as #2 above) and your destination (same as #4 above). It might look something like this:

Input first point: (2.1 , 1.5)

Input second point: (1 , 2)

8) Select "Calculate DISTANCE" like this:

Calculate: ⭘ **Distance (default)**

9) Record your calculated distance here: d(A,B) = 13/10

10) Compare your original calculation to the distance calculation that the website helped you calculate. Are they the same or different? Why do you think they are different?

The distance was different. On the map, I could have gone a detour route. I think the website used the shortest/fastest ^direct route.

10) Repeat steps 1-9 above for two more distances. You might want to go from your favorite store to a restaurant?

Record your math here:
Second calculation:

Starting point: x = 2.2, y = 2.3

Ending point: x = 1.3, y = 1.2

Your distance (counting the squares) = 20 blocks

Calculated distance = ≈1.4213

****

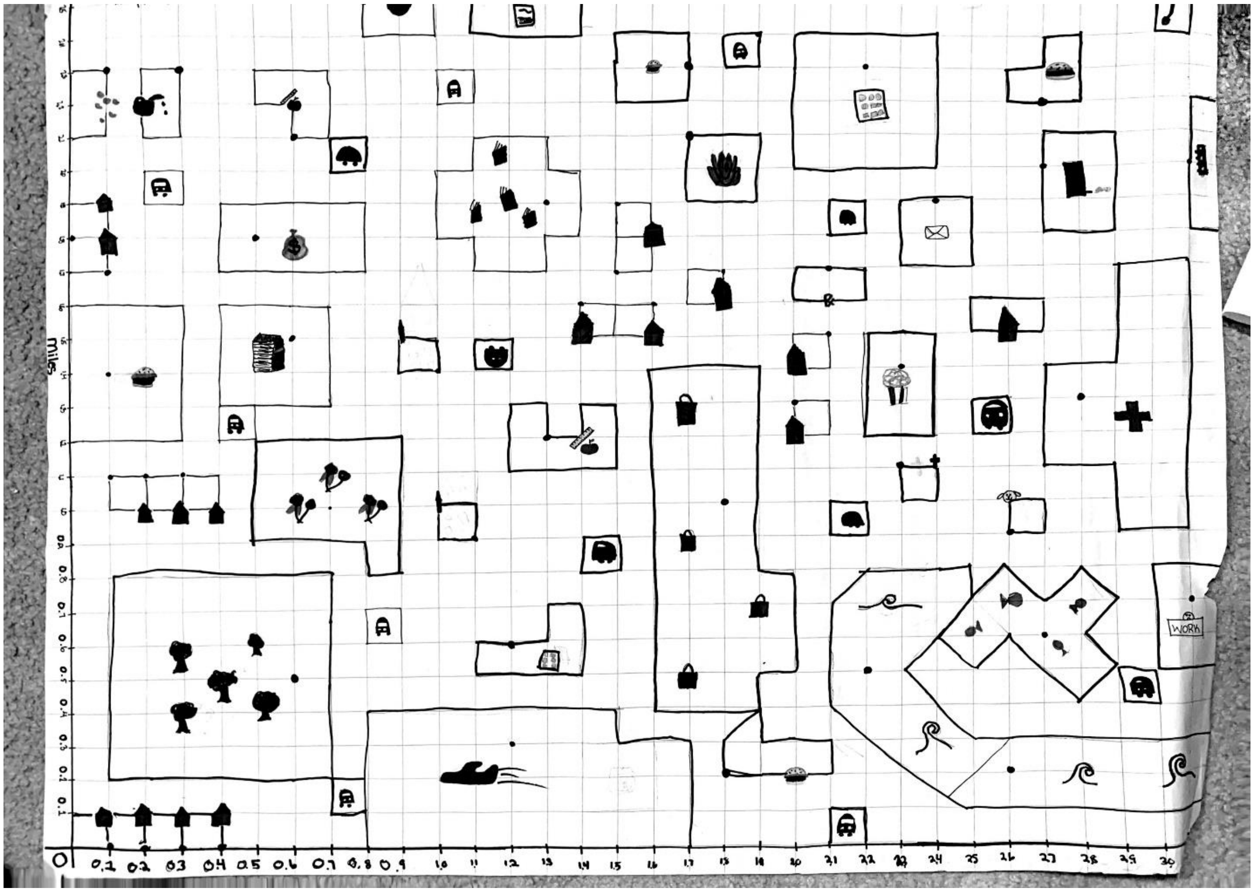
Third calculation:

Starting point: x = 0.5, y = 1.8

Ending point: x = 2.3, y = 1.4

Your distance (counting the squares) = 22 blocks

Calculated distance = ≈1.8439


miles
WORK

Appendix C: Lesson Plans

Days 1-2: City Planning Checklist

Teacher's Name: Mr. Liang | **Subject/Course: Mathematics**
Unit: Proportions and Rates | **Grade Level: 6**

Overview of and Motivation for Lesson: Students will utilize their knowledge of various topics to aid them in the development of a city-themed project.

<table>
<tr><th colspan="2">Stage 1 - Desired Results</th></tr>
<tr><td colspan="2">Standard(s):
Ratios and Proportional Relationships (7.RP)

A. Analyze proportional relationships and use them to solve real-world and mathematical problems. 1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.</td></tr>
<tr><td>Aim/Essential Question:
How can we apply mathematical concepts to city planning?</td><td>Understanding(s):
Students will understand that . . .

Scale factors can be used to scale down real city dimensions to represent a model of the city on paper.</td></tr>
<tr><td>Content Objectives:
Students will be able to:
Use their prior knowledge of various math topics to assist them in the initial planning stages of this project.</td><td>Key Vocabulary
Knowledge of area, perimeter, Measurements(distance), unit conversion would be useful, Square roots, exponents, Polygons, Coordinates/graphs, Scaling, Angles</td></tr>
<tr><th colspan="2">Stage 2-Assessment Evidence</th></tr>
<tr><td>Performance Task or Key Evidence
In their groups, students will construct a model city that fulfills the given criteria:
Students will effectively utilize a coordinate grid to display their model city.</td><td>Key Criteria to measure Performance Task or Key Evidence
Students will correctly utilize a coordinate grid to display their model city.</td></tr>
</table>

Stage 3- Learning Plan

Do Now (10 mins):
What are the necessary components of a town/city? Students will write down 5-7 ideas, then share with rest of class.

Activity 1(20-25 mins)
Students will form groups of 4 and are given a checklist to fill out. The checklist entails basic features of the city such as: population, map scale, landmarks, etc.

Activity 2(rest of class)
If students are done with checklist ahead of time, in their individual groups, they may begin to brainstorm a rough sketch of city model.

Application: City planning incorporates a real life element to math that prompts students to think critically using the various concepts that they have learned in math over the past years. The combination of those topics serves to answer the common question, "When will I use [math concept] in my life?"

Skills Addressed:
- **Problem Solving**
- **Interpersonal**
- **Logical**

Student Grouping:
- **Groups of 4**
- **Whole Class**

Instructional Delivery Methods:
- **Teacher Modelling**
- **Group Discussion**

Accommodations
- Keywords and concepts will be used repeatedly in examples.
- Brief review of prior topics utilized in this lesson during the Do Now.

Homework/Extension Activities:
(Up to teacher)

Materials and Equipment Needed:
- Writing utensils
- Projector
- Graphing Paper

Days 2-3: Developing the City + Transit System

Teacher's Name: Mr. Liang **Subject/Course: Mathematics**
Unit: Proportions, Rates, and Equations **Grade Level: 6**

Overview of and Motivation for Lesson: Students will utilize their knowledge of various topics to aid them in the development of a city-themed project.

<table>
<tr><th colspan="2">Stage 1 - Desired Results</th></tr>
<tr><td colspan="2">Standard(s):
Ratios and Proportional Relationships
7.RP
A. Analyze proportional relationships and use them to solve real-world and mathematical problems. 1. Compute unit rates associated with ratios of fractions, including ratios of lengths, areas, and other quantities measured in like or different units.
8. EE
B: understand the connections between proportional relationships, lines, and linear equations.</td></tr>
<tr><td>Aim/Essential Question:
How can mathematical concepts be utilized in the context of a city?
How does math apply to transit and travel?</td><td>Understanding(s):
Students will understand that . . .

Proportions are essential in providing a conversion of real life distance onto a sizeable distance that fits on a smaller coordinate grid.</td></tr>
<tr><td>Content Objectives:
Students will be able to:
Use their prior knowledge of scaling to help them create a realistic transit system in their city.</td><td>Key Vocabulary
Scaling, rates, distance formula</td></tr>
<tr><th colspan="2">Stage 2-Assessment Evidence</th></tr>
<tr><td>Performance Task or Key Evidence

In their groups, students will construct a model city while effectively utilizing a coordinate grid to develop a transit system….</td><td>Key Criteria to measure Performance Task or Key Evidence

… In addition, students will use mathematical calculations to check for distance between various stops, provide justification.</td></tr>
</table>

Stage 3- Learning Plan	
Do Now (10 mins): Scale factor, proportions review. **Activity 1(25-30 mins)** Students are given a rate of travel over distance, and using this to create their own transit system. Students will make logical choices of where to place transit stops, as well as providing explanations and calculations to justify. **Activity 2(rest of class)** Students will also be asked to find distance between various stops. An introduction to the distance formula will be given. **Application:** City planning incorporates a real-life element to math that prompts students to think critically using the various concepts that they have learned in math over the past years. The combination of those topics serves to answer the common question, "When will I use [math concept] in my life?"	
Skills Addressed: ● **Problem Solving** ● **Interpersonal** ● **Logical** **Student Grouping:** ● **Groups of 4** ● **Whole Class**	**Instructional Delivery Methods:** ● **Teacher Modelling** ● **Group Discussion** **Accommodations** ● Keywords and concepts will be used repeatedly in examples. ● Brief review of prior topics utilized in this lesson during the Do Now.
Homework/Extension Activities: (Up to teacher)	**Materials and Equipment Needed:** ● Writing utensils ● Projector ● Graphing Paper

Days 4-5: Franchise Management

Teacher's Name: Mr. Liang **Subject/Course: Mathematics**
Unit: Percents and Rates **Grade Level: 8**

Overview of and Motivation for Lesson: Students will utilize their knowledge of various topics to aid them in the development of a city-themed project.

Stage 1 - Desired Results	

Standard(s):
• 8. EE
  ○ B: understand the connections between proportional relationships, lines, and linear equations.
• 8. F
  ○ A: Define, evaluate, and compare functions
  ○ B: Use functions to model relationships between quantities.	

Aim/Essential Question: • How can mathematical concepts be utilized in the context of a city? • How can we use mathematics to help us manage various aspects of franchises?	**Understanding(s):** *Students will understand that . . .* Percents, functions, and equations play a large part in calculating revenue in franchise management.
Content Objectives: *Students will be able to:* *Use their prior knowledge of various math topics to assist them in the initial planning stages of this project*	**Key Vocabulary** Percents, equations, functions, variables
Stage 2-Assessment Evidence	
Performance Task or Key Evidence *In their groups, students will construct a model city while effectively utilizing a coordinate grid to display their model city.*	**Key Criteria to measure Performance Task or Key Evidence** *Students will effectively and correctly use percentages and using variables to solve for linear equations.*
Stage 3- Learning Plan	
Do Now(10 mins): Percentages, percentage rates increase and decrease review **Activity 1(20-25 mins)**	

In their groups, students will be given a random franchise to “expand upon” from a bag containing cards that detail various real-life franchises.

Students will research the franchises given in their group in regards to marginal revenue, profits, salaries to employees, etc. and answer various questions pertaining to percents and rates.

Activity 2(rest of class)
Students will be asked to complete feedback form.

Application: City planning incorporates a real-life element to math that prompts students to think critically using the various concepts that they have learned in math over the past years. The combination of those topics serves to answer the common question, “When will I use [math concept] in my life?”

Skills Addressed:

- **Problem Solving**
- **Interpersonal**
- **Logical**

Student Grouping:

- **Groups of 4**
- **Whole Class**

Instructional Delivery Methods:

- **Teacher Modelling**
- **Group Discussion**

Accommodations

- Keywords and concepts will be used repeatedly in examples.
- Brief review of prior topics utilized in this lesson during the Do Now.

Homework/Extension Activities:
(Up to teacher)

Materials and Equipment Needed:

- Writing utensils
- Projector
  - Worksheet/Packet
- Graphing Paper

Day 5+ Extension LP: Spread of Flu

Teacher's Name: Mr. Liang **Subject/Course: Mathematics**
Unit: Graphing **Grade Level: 8**

Overview of and Motivation for Lesson: Students will combine their knowledge of concepts from various topics to aid them in the development of a city planning project.

<table>
<tr><th colspan="2">Stage 1 - Desired Results</th></tr>
<tr><td colspan="2">Standard(s):
8. F
A: Define, evaluate, and compare functions
Use functions to model relationships between quantities.</td></tr>
<tr><td>Aim/Essential Question:
How can mathematical concepts be utilized in the context of a city?
How is math relevant in predicting a flu outbreak?</td><td>Understanding(s):
Students will understand that . . .

Predicting and monitoring bacterial growth can be represented via exponential growth formula.</td></tr>
<tr><td>Content Objectives:
Students will be able to:
Use their prior knowledge of various math topics to assist them in the initial planning stages of this project</td><td>Key Vocabulary
Variable, formula, exponential, regression</td></tr>
<tr><th colspan="2">Stage 2-Assessment Evidence</th></tr>
<tr><td>Performance Task or Key Evidence

In their groups, students will use their algebraic skills to aid them in solving elementary exponential growth problems</td><td>Key Criteria to measure Performance Task or Key Evidence

In their groups, students will use their algebraic skills to correctly solve elementary exponential growth problems</td></tr>
<tr><th colspan="2">Stage 3- Learning Plan</th></tr>
<tr><td colspan="2">Do Now(10 mins):
Exponents, solving equations algebraically review

Activity 1(20-25 mins)
In their groups, students will all receive a case of flu spreading around in a hospital in their city. A formula will be given and students will be asked to record the data in a</td></tr>
</table>

table and a graph. Students will use this data to compare and contrast with another set of flu outbreak data.

Activity 2(rest of class)
Students will be asked to complete feedback survey.

Application: City planning incorporates a real-life element to math that prompts students to think critically using the various concepts that they have learned in math over the past years. The combination of those topics serves to answer the common question, "When will I use [math concept] in my life?"

Skills Addressed:
- **Problem Solving**
- **Interpersonal**
- **Logical**

Student Grouping:
- **Groups of 4**
- **Whole Class**

Instructional Delivery Methods:
- **Teacher Modelling**
- **Group Discussion**

Accommodations
- Keywords and concepts will be used repeatedly in examples.
- Brief review of prior topics utilized in this lesson during the Do Now.

Homework/Extension Activities:
(Up to teacher)

Materials and Equipment Needed:
- Writing utensils
- Worksheet/Packet
- Graphing Paper

Appendix D: Survey Questions

Hello everyone. My name is Yu Liang, I am a college senior from WPI that is currently doing a research on the interest of Math in our middle school classrooms. I would really appreciate it if you can provide me your honest feedback on the questions below.

Thank you for your time!

I like math class. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Math has many applications in real life. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I use different methods to solve math problems. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Name at least 3 things in your life that involves math: *

Short answer text

What do you believe is the best method or skill set for doing well in math? *

- ○ Good memory - I can just memorize everything in class!
- ○ Plenty of practice - practice makes perfect right?
- ○ Patience - breaking down a problem step by step, and using what I know.
- ○ Being naturally good at it.
- ○ Other (If you have a different answer than the ones above, or if you wish to elaborate, please explain briefly in the fol...

(Other) If you have a different answer, or if you wish to elaborate, please explain briefly below.

Long answer text

How would you describe your work habits for math assignments? *

- ○ I get it done as early I can so I don't have to deal with it later.
- ○ I like to spread out the work evenly over a period of time.
- ○ I do it the day before it's due/I'm up all night.
- ○ I don't care for due dates.

Do you give yourself enough time to complete assignments after school on a daily basis? *

	1	2	3	4	5	
Not at all	○	○	○	○	○	More than enough time

What math topics are you confident in? List them briefly. *

Long answer text

What math topics do you tend to struggle in? List them briefly. *

Short answer text

List at least one job that involves math.

Short answer text

In the future, I am interested in pursuing a career that involves math. *

- ○ Yes
- ○ No
- ○ Not sure

If you answered Yes, what type of a job? If else, and you're willing to share, what are your concerns?

Short answer text

Group Project Based Learning Experiences

Please rate the following statements based on your experience with this city planning project, as well as any group work opportunities you may have in class.

How productive are you during group work? *

	1	2	3	4	5	
Not productive at all	○	○	○	○	○	Very productive

When I didn't understand something on a group project, my group was able to help me understand. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Working alongside other students in groups made the problem-solving process easier. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I believe group projects are helpful because they allow me to gain different perspectives by working with others. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Do you enjoy working in groups? *

◯ Yes

◯ No

Do you have any concerns in regards to working in groups?

Short answer text

What is the gender you identify as?

◯ Male

◯ Female

◯ Choose to not answer