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UNIVERSITY OF CALIFORNIA, SAN DIEGO

Google Your Math:
Sustaining a Sociocultural Environment through Collaborative Online
Participation in Algebra

A Thesis submitted in partial satisfaction of the requirements
for the degree Master of Arts

in

Teaching and Learning (Curriculum Design)

by

Kimberly Anne OBrien Samaniego

Committee in charge:

James Levin, Chair
Cheryl Forbes
Bernard Bresser

2010

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Chair

University of California, San Diego
2010

DEDICATION

For “my” Tony

*Who believes in me and supports me in all my endeavors
to become a better educator, parent, spouse, and partner in life.*

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ABSTRACT OF THE THESIS

Google Your Math:
Sustaining a Sociocultural Environment through Collaborative Online
Participation in Algebra

by

Kimberly Anne OBrien Samaniego

Master of Arts in Teaching and Learning (Curriculum Design)

University of California, San Diego, 2010

Professor James Levin, Chair

This curricular project explores how students used Google online environments to sustain the aspects of sociocultural learning through student collaboration and dialogue instrumental in the math classroom. The students in this project were from two 10th grade Algebra 1 classes in a culturally diverse San Diego public high school. Using knowledge-building principles, online dialogue and collaborative activities were created to increase student practice of algebra at home and to increase both conceptual understanding

and procedural fluency. Theories of motivation regarding student choice, flexible environments, and receiving feedback were integral factors in this project design. The research found the online Google environments equitably accessed by all students - particularly students with learning disabilities and students from minority populations. Additionally, more students practiced algebra at home during implementation. The data showed that students used Google activities for knowledge sharing and problem solving in math. The results from pre and post-implementation assessments found the greatest overall improvement from students who participated online as well as evidence of narrowing achievement gaps in mathematical performances between student populations. While Google was not a substitute for classroom instruction, it did promote student peripheral participation (Lave & Wenger, 1991) in a learning community for algebra. The activities described in this project are not specific to algebra but can be applied to other math class as well as to different subject areas.

I. Introduction: Sociocultural Learning in Algebra

The following vignettes originated in my tenth grade Algebra 1 classroom at Needmore High School (NHS) in the Southern Unified School District (SUSD) where students were repeating algebra after failing it in their freshman year. The names of all students and teachers, school, and districts in this document are pseudonyms. Both vignettes take place during the second month of school while students are working on algebra lessons in small groups. I am monitoring student progress and listening to their interactive dialogue. In both cases, the students and I gain valuable learning through student voice.

Vignette 1

Jose just moved to the United States from Mexico. Jose does not speak English. However, he is still able to contribute to the learning environment through peer-student translators. In collaborative group activities, it is common to see students speaking both English and Spanish with one or two students translating. During one of these activities, students were finding the least common multiple (LCM) of 5, 12 and 18 and I noticed Jose had found the correct answer quite quickly. Angelo, a group member and peer translator, asked him how he got his answer. Curious, I sat down to listen. Angelo translated between the two languages, making meaning for me and making meaning for Jose. After several minutes, Jose taught us both a new method for finding the LCM. The next day, I presented Jose's method on the board as one of many methods that students were using.

Next, a class discussion took place about why, conceptually this method worked. If my agenda had been to teach my students the “one” method or procedure for finding LCMs, I would not have learned Jose’s method, nor would I have had the pleasure of sharing his method with other students who can now use it. In this case, by allowing my students to discuss the ideas and methods of others, I became what Friere (2008) calls a teacher who is, “taught in dialogue with the students” (p. 80).

Vignette 2

Kalisha is a social and assertive tenth-grade African American teen. Behind in credits, she expresses motivation and interest in excelling in this year’s class. She is currently earning an A, which both elates and surprises her. One day, while working in her group, she began asking other students who their ninth grade teacher for Algebra 1 was. All students readily offered up their teachers’ name as well as their comments regarding those teachers, the class, and their viewpoints as to why they had failed. Most students commented on pacing and on not understanding. Kalisha stated that she liked my class because she believed that she could do the math. When I asked her what the difference was, she indicated that she was more confident because she had learned the material at her own pace. I found her next comment especially enlightening, “Last year, if you got behind, you were just off the bus. And once you were off the bus, you could never get back on.” Kalisha knows through daily experiences, that missing the bus represents missed opportunities for learning, for interactions with her peers, and ultimately, for graduating from high school.

Students like Jose and Kalisha represent not only the learners in the tenth grade algebra classes at my school but also students in the district, state, and nation who perform lower on standardized assessments and who repeat Algebra 1 at greater rates than their White peers. Since Algebra 1 is the first of

three math classes required to pass high school in California, what types of practice contribute to greater academic success in Algebra 1? How do sociocultural communities that promote student collaboration and dialogue contribute to cognitive learning in the math classroom? What is the relationship between student motivation and conceptual understanding of mathematics? And lastly, how do students sustain this type of learning outside the classroom?

This project explored sociocultural communities of collaboration and discourse, specifically, the effects of these communities on motivation and conceptual understanding in algebra and methods to sustain these communities outside of the classroom. Finding answers to these questions guided the design and facilitation of a collaborative online domain where students had opportunities to stay connected and to receive peer and teacher feedback. In support of my research, this domain provided opportunities for me to collect data on student motivation and mathematical progress as they learned algebra.

II: The Need for Equitable Practices in Teaching Algebra

Although California students who take Algebra 1 in the ninth grade receive instruction containing the same standards-based criteria, not all students experience similar levels of algebraic success. As presented in the introductory vignettes, Jose and Kalisha are two such students, both members of student populations that typically perform lower than White students. At local, district, and state levels, students who are disabled, socioeconomically disadvantaged, English language learners (ELLs), Hispanic, and African American perform at lower levels than White, Asian, and Filipino students (CST, 2009; Nation's Report Card, 2009). This disparity, and interventions designed to address it, are complicated by the implementation of No Child Left Behind (NCLB, 2001), a mandate that places national focus on student achievement in core classes and makes test preparation a necessary guideline for the content coverage of prescribed curricula.

In order to explain possible reasons for student achievement gaps, Boaler and Staples' (2008) research on current instructional practices in math classrooms show more teachers use a *transmission* model, an approach in which knowledge is transmitted from the teacher to the student and learning results from memorizing facts and applying them to different situations (Wink

& Putney, 2002). For Boaler and Staples (2008), the transmission model differs from *investigative* learning experiences in which students build broad relational understandings of mathematics through carefully planned activities (Jaworski, 1997).

Freire (2008) argues that the transmission model challenges equitable learning. He defines this model as the *banking concept of education*, in which teachers are the sole givers of knowledge and students are empty vessels waiting compliantly, to be knowledge filled. In this banking analogy, knowledge is bestowed like a gift by those considered knowledgeable to those considered ignorant. This manner of teaching minimizes the students' creative power and what Freire refers to as their critical consciousness or their consciousness of the dominant and oppressive systems operating in their lives and which generates possibilities for meaningful responses. According to Freire (2008), teachers who use the banking model, take experiential learning away from students and relying on their ability to cover topics in order to promote student achievement, also provide fewer chances for students to take ownership of their own understanding and learning.

Ten years ago, I worked with district teachers to write an Algebra 1 curriculum that incorporated thematic units built around big ideas with a

central project motivating the mathematical learning. In support of our curriculum, the board agreed to move many of the most abstract topics of Algebra 1, such as rational expressions and solving quadratic equations, to Geometry while at the same time bringing more contextual topics from Geometry, such as area, perimeter, and the Pythagorean Theorem, into Algebra 1. The reason for this rearrangement of topics was to support algebra access to all students and for a limited time, students experienced higher pass rates. However, since NCLB, this school district has reversed its decision and has abandoned the teacher-created curriculum in favor of more traditional approaches that not only cover all the topics on the California Standards Test (CST) for Algebra 1, but tacitly promote more traditional methods which are focused on coverage rather than understanding.

Attempting to cover all the standards in the course objectives for Algebra 1, the teachers in my current department opt out of projects and contextual problems favoring banking and transmission models of direct instruction believing that this approach is more time effective. As a result, students learn procedures for doing math without conceptual understanding of why the procedure is used, what it will do, and why it is important. According to Van de Walle (2003), learning a procedure does not develop

procedural fluency. In order for students to obtain mathematical proficiency, students must also be able to carry out the procedure flexibly, accurately, efficiently, and appropriately. Additionally, he explains that procedural fluency is only one of five strands of mathematical proficiency, the other four being: conceptual understanding, strategic competence, adaptive reasoning, and productive disposition.

Stigler and Hiebert (1999) illustrate effective teaching techniques advanced during Japanese lessons on problem solving. These approaches, which have generated student success in mathematics, promote students' exploration of desired mathematical concepts by allowing them to work on difficult problems independently, in groups, and during whole class discussions. Looking internationally, studies show that math students in Japan experience significantly higher mathematical success than US students (TIMMS, 2007).

International and National Performances in Eighth Grade Mathematics

According to the Trends in International Mathematics and Science Study (TIMSS) of 2007, students in the US scored ninth worldwide out of 48 participating countries on a scaled achievement assessment showing an improvement of 16 points in their mean scores since 1995. However, this

improvement still reports US students significantly lower than students from China, The Republic of Korea, Singapore, Hong Kong, and Japan. As Table 1 shows, only 6% of US students scored *advanced* which is significantly lower when compared to China at 45%, Korea at 40%, Singapore at 40%, Hong Kong at 31%, and Japan at 26%.

Table 1: 2007 TIMMS Comparisons of US to Top Performing Countries
Significance of Mean Scores and Percent Proficiency for 8th Grade Math Achievement

Country	Mean 2007	p < .05 2007 Mean	% Advanced 2007	p < .05 2007 Advanced
Chinese Taipei	598	Yes	45	Yes
Republic of Korea	597	Yes	40	Yes
Singapore	593	Yes	40	Yes
Hong Kong	572	Yes	31	Yes
Japan	570	Yes	26	Yes
Hungary	517	No	10	No
England	513	No	8	No
Russian Federation	512	No	8	No
United States	508	No	6	No

While Table 1 shows the eighth grade result for the 2007 TIMSS scale average of 500, Figure 1 shows the trends over time on the same assessment for African American and Latino students when compared to the performances of White students in the US. While slight improvement for all three student populations is shown, African American and Latino students are consistently performing lower than their White peers. In 2014, NCLB will

mandate that all students perform *proficient* or higher on state tests in English and mathematics. While the TIMSS represents one assessment result, similar gap trends of student performances are mirrored again on the National Assessment of Educational Progress (NAEP) as well as on the state, district, and school CST in mathematics.

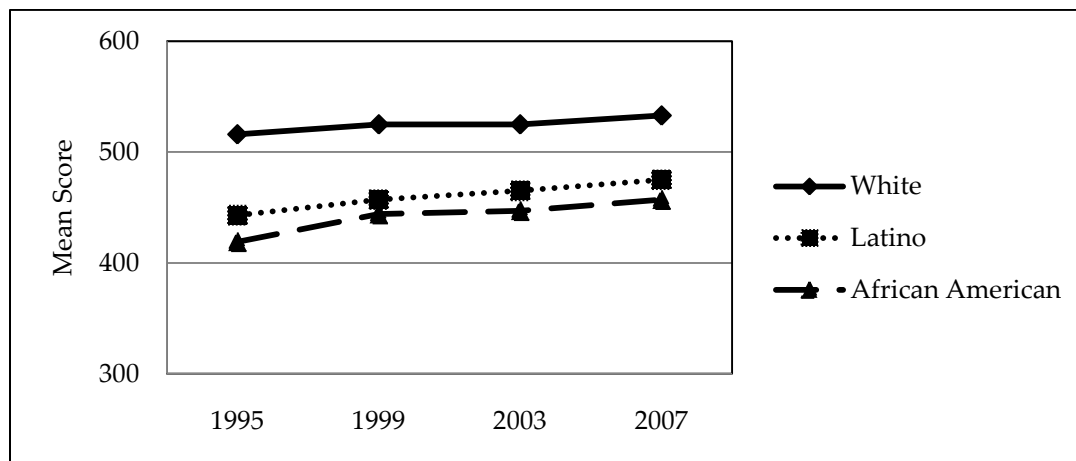


Figure 1: Achievement Gap in 8th Grade Math TIMSS Assessment

Given to students in eighth grade math, the NAEP evaluates students' understanding of mathematical concepts showing increased performance from 2005 to 2007 in most categories (NAEP, 2009). However, significant differences in scores continue to exist between White students and their African American and Latino peers. In 2007, the gap between White and African American student performances was 32 points, and between White and Latino students the gap was 26 points. While these gaps have decreased

since 1990 for both African American and Latino students, this change is not significant. The NAEP (2009) also shows California being among 26 states showing no significant change in algebra scores from 2005 to 2007. Looking at state and district trends for algebra students provide detailed insight to educators wishing to promote equitable mathematical performance.

State and District Performances on CST

The following data focus on the performance of California students in ninth grade who took the CST for Algebra 1. Interestingly, the same gap trends that occurred at the national level are also experienced by California students, Southern Unified students, and students from Needmore High School. At both the state and district levels, students did not meet AYP target proficiency rates of 34.0% in 2008 and 45.5% in 2009 for some populations. Additionally, Figures 2 and 3 show ELLs, students with socioeconomic disadvantages, Latino, African American, and students with disabilities score not only below their White peers, but also lower than averages for both state and district students (CST, 2009).

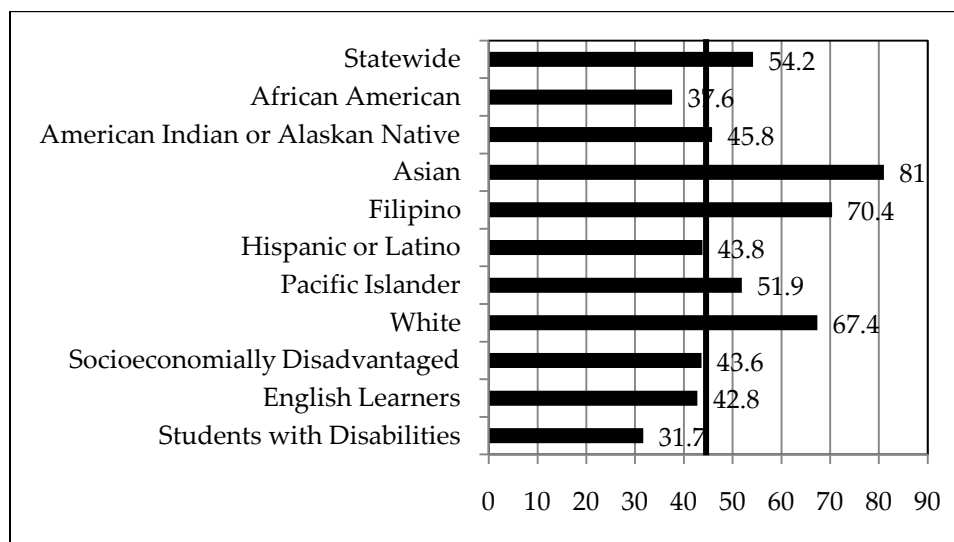


Figure 2: California AYP 2009 Mathematics
 Percents *At or Above Proficient* – Did Not Meet Proficiency Target of 45%

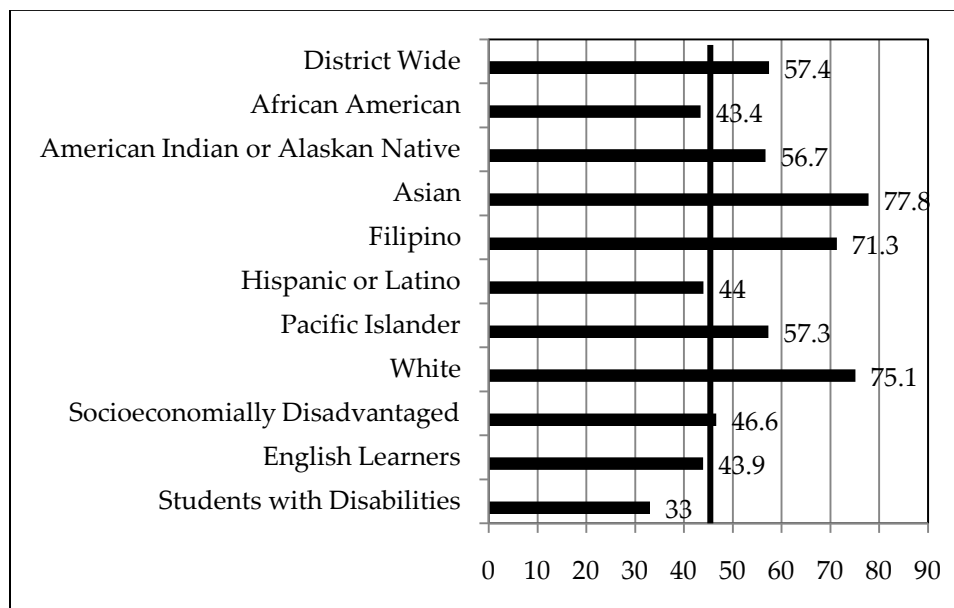


Figure 3: Southern Unified School District AYP 2009 Mathematics
 Percents *At or Above Proficient* – Did Not Meet Proficiency Target of 45.5%

These trends are consistent with reports from TIMSS and NAEP with African American and Latino students scoring well below their White peers.

Figure 4 shows similar performance gaps at Needmore High School even though the school met their AYP target goals for all sub groups.

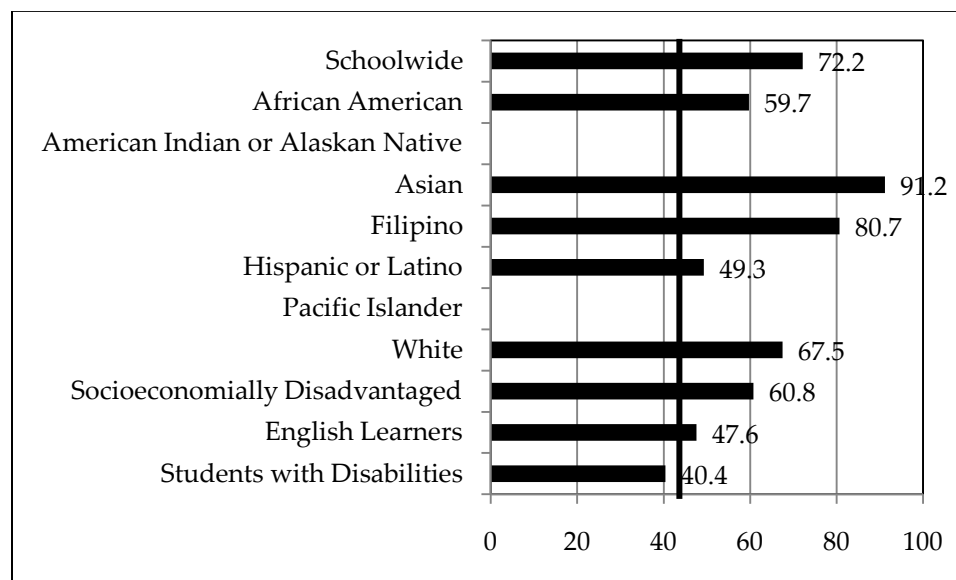


Figure 4: Needmore High School AYP 2009 Mathematics
 Percents *At or Above* Proficient – Did Meet Proficiency Target of 43.5%

School Wide Data for Ninth Grade Algebra 1

While Needmore High School met target projections in math for AYP in 2009, clearly they are not immune to achievement gaps especially regarding ninth grade students in Algebra 1. Figure 5 shows that while all student populations made significant improvement in student proficiency from 2008 to 2009, the gap actually widened for ELLs as well as for African American and Latino students. Discrepancies in achievement reveal the need for educators to look closely at instructional practices at Needmore High School

in order to design curricula that meets the needs of more student populations (CST, 2009; CST, 2008; CST, 2007; CST, 2006; CST, 2005; CST, 2004).

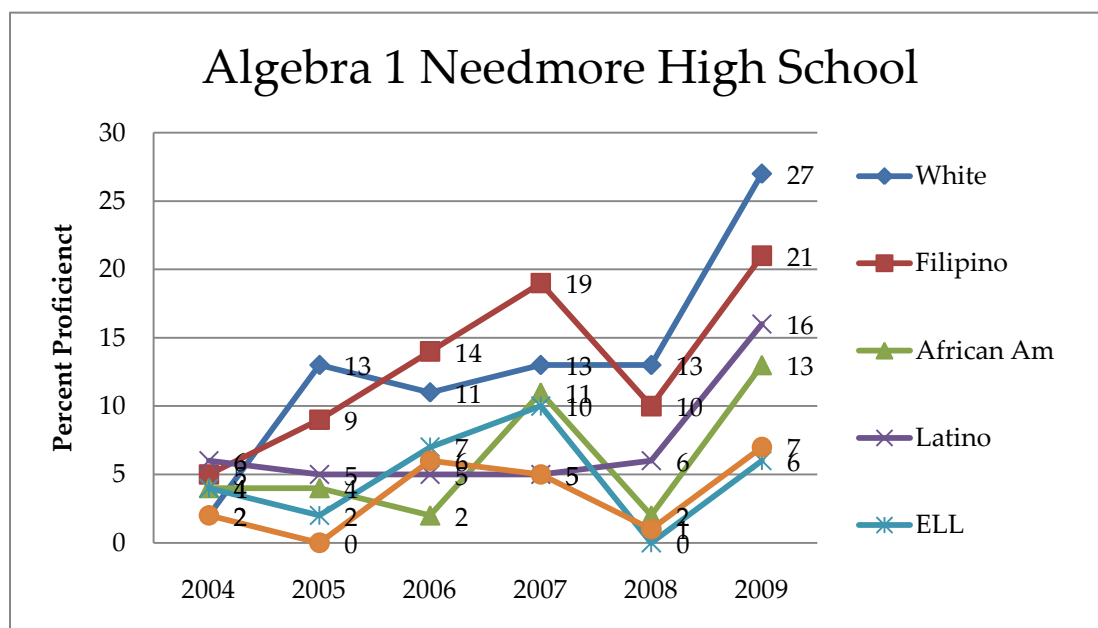


Figure 5: Achievement Gaps for NHS Students on CST

Classroom Implications

As a ninth grade Algebra 1 teacher for the past 15 years, I find it most challenging to support all students in my diverse classroom setting. By identifying algebra as an eighth grade standard, all students who take algebra in the ninth grade are, according to the state of California, behind in grade-level standards and many students enrolled in ninth grade algebra took algebra in the eighth grade without success. Among this population, not all students perform equally well in standards-based assessments as

demonstrated by the preceding data. Finding ways to motivate and improve the skills of students who are ready for algebra while at the same time providing support and scaffolds of remediation for students who are not at grade level are the most important concerns in my lesson designs.

In order to graduate from high school, the state has determined that every student must pass three years of high school math with Algebra 1 being the first and entry level year. Additionally, in order to be accepted to a four-year college, students must pass Algebra 2 with a C or better. Algebra 2 is the third year of high school math with Algebra being the first prerequisite course. A greater emphasis is now placed on passing Algebra 1, making it a gateway course to college entrance. With the severe budget cuts lowering the number of local students accepted to California colleges, being college-ready is even more important. Thus, students who do not pass Algebra 1, Geometry, and Algebra 2, do not meet minimum requirements for admittance to a four-year college. Therefore, it is more important for students to be proficient in algebra in order to meet the competitive demands for college entry.

But, the reality is that approximately 40% of all students in Southern Unified School District do not pass Algebra 1 with a C or better in the ninth grade, and many go on to repeat in the tenth grade. At Needmore High

School, the pass rates are slightly higher with approximately one-third of all ninth grade students repeating Algebra 1 in the tenth grade.

During this project's implementation, I taught Algebra 1 to tenth grade students whose population mirrored district figures. Out of 39 total students, 10 had Individual Educational Plans (IEPs) in math, eight were ELL, 11 were African American, and 12 were Latino. Not only were these students at risk for not graduating, they also illustrated the achievement gaps experienced at Needmore High School in Algebra 1 the previous year.

Potential Reasons for the Trends

When looking at trends over time, the NAEP shows that achievement gaps narrowed for African American-White and Latino-White students in the 1970's and the 1980's yet increased again in the 1990s. Lee (2002), concludes that indicators for White, African American, and Latino students regarding family economics, student drug use, perceived student safety at school, school funded programs, student motivation, and student interest do not explain the decrease in minority performances and the increase in White performances. However, one trend that appears to be relevant is the African American-to-White high school dropout rate which showed no change in the African American student dropout rates but a decrease in dropouts for White

students. This dropout pattern relates closely with that of the African American-White achievement gap. Additionally, this study shows that the dropout rates for Latino students is higher than those for both African American and White with little changes in 30 years resulting in a widening of the gap between Latino and White students. Stewart (2008) found that gender, parent involvement, and student involvement in extra-curricular activities were not significant factors regarding academic performances. However, peer influences, student's socioeconomic status, number of parents in homes, and minority classification were significant indicators of academic performances. Gutierrez (1999) and Stewart and Foster (2008) conclude that caring teachers and school staff who provide environments designed to support student identity and individual learning processes are the most important factors in fostering student successes.

Conclusion

Looking at ways to instruct all students to succeed mathematically appears to be a relevant if not critical task for today's educators. Studies show students experience improved mathematical performances when student-centered curricula of investigation and mathematical discourse are implemented (Boaler & Staples, 2008; Gutstein, 2007; McKinney, Chappell,

Berry & Hickman, 2009; Slavin, Lake & Groff, 2009; TIMSS, 1999). Boaler and Staples (2008) report the concurrent narrowing of achievement gaps showing Latino and African American students performing similarly to White students when student-centered curricula are used for mathematics instruction. The National Council of Teachers of Mathematics NCTM (2000) maintains that the key to improved student performance relies on the planning and delivery of inquiry-driven lessons that focus on conceptual understanding. However, research indicates that teachers continue to implement traditional methodologies of lecture and direct instruction more often than using student-centered approaches (Boaler & Staples, 2008; McKinney et al., 2009). This is true even though these traditional approaches may not contribute to a school climate that promotes the improvement of student performance (Gutierrez, 1999; Stewart & Foster, 2008). As instructional debates regarding best practices continue, gaps in achievement continue to grow. In order to meet students' needs, my research investigated practices that addressed achievement gaps in order to promote the mathematical proficiency of more students.

III. Review of Literature

Mathematical proficiency is a combination of both conceptual and procedural understanding (NCTM, 2000). According to Van De Walle (2003), conceptual understanding is an important component of procedural fluency implying that teaching procedures without developing concepts is counterproductive to improving students' mathematical understanding. The NCTM (2000) provides a framework for *mathematical discourse* in which students debate, question, explore, and investigate why and how mathematics works in order to help students make meaning of the abstraction of algebra. These characteristics align with the NCTM Process Standards (2000) of problem solving, communication, connections, reasoning and proof, and representation. Vygotsky (1986) theorizes that concept attainment results from interpreting information through the use of both thought and language. Traditional methods of lecture and chalk talk used in many high schools do little to support the language and thought necessary for student comprehension. Researchers search for methods that support mathematical understanding through curricular designs. Gutstein (2007) proposes that students who are engaged in socially relevant problem solving are more motivated to learn mathematics and achieve higher levels of mathematical

success on formal assessments. His instructional practices support Freire's (2008) philosophy of *problem posing dialogue*, which is a socially active, participatory instructional practice that allows students to co-investigate relevant concepts while in dialogue with their teacher.

Deci (1995) theorizes about the reciprocal relationship between students' understanding and their motivation to achieve. When students understand, they have an increased intrinsic motivation to achieve, which then leads to content competency and confidence which may explain why some students are motivated more than others to perform tasks in the classroom. In early stages of development, children purposely ignore topics that they do not understand (Smith, 1998). Consider a child in play who walks away from one activity only to immediately engage in a different one – a behavior that is most likely explained not by boredom, but by the fact that the child simply does not understand the activity. As a result, the child ignores the activity. Later in school, when students do not understand a math lecture, they will most likely disengage in active note taking and learning entirely. Deci (1995) and Smith (1998) attribute this later behavior to the lack of student autonomy since they no longer can walk away from the activity without detrimental consequences. This example illustrates the following

dichotomy: in order for engagement to take place, understanding is crucial, yet in order for students to be engaged or motivated, they must understand and experience competency. Therefore, in order to promote content mastery in algebra, research suggests looking at practices that are intrinsically motivating, that balance conceptual understanding and procedural fluency, and that encourage collaboration and language discourse.

Collaborative Environments in the Social Classroom

Meaning-seeking instruction involves students working in a collaborative environment where ideas are the currency of the classroom and have the potential to contribute to everyone's learning (Hiebert et al., 1997). Student centered classrooms provide ample opportunities for students to work together and learn together. According to Vygotsky (1978), teaching and learning co-exist in a cohesive and flexible environment where, in collaboration with others, students reach beyond their current ability to solve problems. To support this, the classroom needs to be a safe place where every student's voice is not only heard but respected. The instructional practices in this type of classroom environment build trust and respect among all participants. Freire (2008) seeks to dismantle the banking concept by transforming the traditional teacher-student relationship into one where the

teacher is not solely “the-one-who-teaches, but one who is himself taught in dialogue with the students, who in turn while being taught also teach” (p.80). In this type of instruction, the teacher presents material to students for their consideration creating conditions where knowledge is obtained and expressed and where ideas can be exchanged and reconsidered.

Collaborative discourse in learning.

The pedagogical beliefs of both Vygotsky and Freire support student-centered learning environments that are social and collaborative as well as interpersonal. Students in this researcher’s classroom are tenth grade students who have taken and failed Algebra 1 in the ninth grade. They are diverse in skill sets, mathematical understanding, and motivation. One-fourth of the students have IEPs and almost another fourth are ELL students who require various teaching strategies to insure comprehension of the content. But, as seen in the needs assessment, students are not on a level playing field with gaps of achievement actually widening instead of narrowing and they are relying on learning environments that favor teacher-dominated whole-class instruction. Cummins (2000) points out serious problems with this transmission model of instruction since students do not have access to communication with both their peers and their teachers. And more

importantly, teachers who use this practice do not see students as being capable of contributing and developing knowledge in social contexts and as a result, “students are silenced or rendered voiceless in the classroom (p. 257).”

Vygotsky (1986) theorizes that thoughts take on new meanings when they are verbalized since word meanings have an association between the word’s sound and its content. Conversely, he adds that without the use of words, thoughts are devoid of meaning. In a mathematics classroom, his theory implies that students who talk about math have an opportunity to connect their abstract ideas to concrete understandings of mathematics. Teachers who deliver lecture-based lessons allow students to only develop internal thought while teachers who create opportunities for students to verbalize their thoughts into words provide students with opportunities to form deeper meanings.

The relation of thought to word is not a thing but a process, a continual movement back and forth from thought to word and from word to thought. In that process, the relation of thought to word undergoes changes that themselves may be regarded as development in the functional sense. Thought is not merely expressed in words; it comes into existence through them (Vygotsky, 1986, p. 218).

In a sociocultural environment, student discourse and collaboration are necessary components to understanding. Students who are not English

language proficient show improved performances in content understanding when they are provided opportunities to construct their understanding of words through dialogue. Cummins (1979) reports that when students are given opportunities to speak in their first languages, deeper conceptual understanding is developed when transferring this knowledge to their second language. Additionally, second language acquisition in collaborative learning environments, which require extensive language use, is an effective way for students to understand both the second language and the course content through dialogue (Krashen, 1976). Within small group talk, students can help translate information, whether from the teacher or from text, can speak in their first languages to explore conceptual ideas, and can then proceed to make meaning in English. With proper scaffolding and peer support, ELL students can access the curriculum and make connections and transfers in learning. "Consciousness is connected with the development of a word...the word is absolutely impossible for one person but becomes a reality for two" (Vygotsky, 1986, p.256).

Collaborative communities in the math classroom.

Slavin et al. (2009) report evidence that collaborative learning has positive effects on the achievement of all students. And according to

McKinney et al. (2009), creating a mathematics learning community through problem solving and reasoning improves student performances and constitutes a quality approach to teaching math. In collaborative classrooms, social norms for group behavior must be nurtured through carefully crafted lessons that require students to offer ideas, listen carefully, build upon ideas, and respect each other (Boaler & Humphreys, 2005). In their case studies, Boaler and Humphreys (2005) state that there are two critical practices to the development of mutual (group) understanding: justification and representation. Their analysis of this study indicates that students who justify their ideas, solutions, and methods share learned knowledge with the group where it then becomes common group knowledge and understanding. Additionally, they show that when students see multiple representations of the same solution, they have more opportunities to find a method that personally connects conceptually promoting deeper understanding. Multiple representations therefore become helpful in communicating ideas and in supporting the mutual understanding of the group.

Student group collaboration results in mathematical discourse that incorporates knowledge from the group of learners, individuals' knowledge, and knowledge gained from the social contexts of both. Collectively, these

influence the final conclusions drawn by the group. When faced with challenging and authentic problem solving, students in *well-defined* heterogeneous collaborative settings, where each member of the group has clearly defined roles or tasks, will experience conceptual growth that is either at or beyond their current level of development. Vygotsky (1978) named this a student's Zone of Proximal Development (ZPD) which is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86).

Motivation in Mathematics

When students are motivated by interesting topics or by activities that promote understanding, increased levels in engagement are evidenced. Additionally, when students are engaged, there exists greater opportunities for improved mathematical performances. Therefore, researching the relationships between motivation, student understanding, and student performances are valuable to lesson design.

The relationship between motivation and understanding.

Motivation has a dynamic relationship to both procedural fluency and conceptual understanding. When students solve problems using standard procedures that have been learned in a rote manner, extrinsic incentives or rewards often facilitate motivation and performance. Additionally, when students perform tasks that are more creative or problematic, extrinsic rewards or controls can have the opposite effect causing diminished motivation and performance (McGraw & McCullers, 1979). Further research indicates that learning environments that are less controlled and more spontaneous facilitate greater student interest and conceptual learning than do environments that are directed and controlled where students feel pressured to complete activities (Grolnick & Ryan, 1987; Ryan & Deci, 2000). Students can be extrinsically motivated through rewards to perform skills such as memorizing and applying formulas but intrinsic motivation is needed to promote conceptual understanding.

The relationship between feedback and motivation.

Teacher feedback is also a determiner of whether or not students will be intrinsically motivated. Deci & Cascio (1972) suggest that when students engaged in intrinsically motivated activities receive positive feedback, they

show an increased tendency to continue the activity even when rewards are not present. Conversely, students who receive negative feedback while engaged in intrinsic activities may exhibit weakened confidence and self-determination making the activity less rewarding depending on the degree of how negative the feedback was or how bad it made the student feel (Deci & Cascio, 1972). In later studies, Deci, Ryan, and Koestner (1999) show that positive feedback enhances both free-choice behavior and self-reported interest while tangible rewards given upon completion of an interesting activity undermine intrinsic motivation for that activity.

The relationship between learning environments and motivation.

In a sociocultural classroom, where student-centered practices of collaboration and dialogue are implemented, peer teaching and tutoring can be used to increase motivation for learning since students who learn with the goal of teaching others develop greater conceptual understanding of the task (Benware & Deci, 1984). Therefore, a collaborative learning environment where peers explain, explore, debate, and defend ideas, methods, and solutions can increase motivation leading to greater conceptual understanding. Additionally, instructional practices that offer students choice, minimize controls, and acknowledge student feelings have the greatest

chance of producing intrinsic motivation which promotes conceptual understanding (Deci, Vallerand, Pelletier, & Ryan, 1991).

The model in Figure 6 represents the researcher's interpretation, from the research, of the reciprocal relationship between motivation, conceptual understanding, and procedural fluency. In this model, extrinsic motivation promotes only procedural development but intrinsic motivation promotes both conceptual understanding and procedural fluency. Additionally, conceptual understanding promotes motivation while procedural fluency does not (Deci, et al., 1991; Van de Walle, 2003).

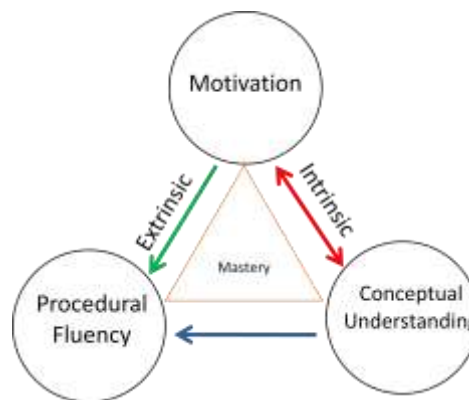


Figure 6: Triadic Model of Motivation Influences

Online Learning Models

Up to this point, collaborative learning environments have been strictly associated with classroom settings where students interact face-to-face with both students and teachers. Collaborative online learning environments

provide alternative points of access to content curricula. Evidence of successful collaboration is possible in online learning particularly when the medium is easy to use (Curtis & Lawson, 2001). Additionally, learning environments that support *autonomy*, encouraging choice, are reported to produce greater intrinsic motivation, interest, cognitive flexibility and conceptual learning (Deci & Ryan, 1987; Ryan & Deci, 2000).

Koschmann (1994) explains that collaborative learning is a model of instruction that honors other types of communication such as peer-to-peer and student-to-teacher interactions rather than the traditional communication of teacher-to-student. Furthermore, he states that research in this area has stimulated interest in educational possibilities that use collaborative technology in education called Computer Support for Collaborative Learning (CSCL). Many CSCL applications involve groups of learners working on different but connected processors and some can be used to mediate communication within and across classrooms. Additionally, computers can provide storage for the work completed by student groups which can lead to knowledge-building practices (Scardamalia & Bereiter, 1991).

Knowledge-Building.

A model that not only supports student learning through Zones of Proximal Development but encourages students to take control of their ZPD's is called *knowledge-building*. In this type of collaborative learning, the goal is not only of subject matter learning but of knowledge-building and scholarly inquiry (Scardamalia & Bereiter, 1991). Knowledge-building represents an attempt to “refashion education in a fundamental way, so that it becomes a coherent effort to initiate students into a knowledge creating culture” (Scardamalia & Bereiter, 2006, p. 98). Knowledge-building consists of six themes that shift the traditional role of student as learners and inquirers to members of a knowledge-building community and are identified as:

- Knowledge advancement as a community, rather than individual, achievement
- Knowledge advancement as idea improvement rather than as progress toward true or warranted belief
- Knowledge *of* in contrast to knowledge *about*
- Discourse as collaborative problem solving rather than as argumentation
- Constructive use of authoritative information
- Understanding as an emergent

A summary of the author's description for each of the six themes is provided.

Community knowledge advancement.

In the first theme, the state of knowledge is not about what is in an individual's head but rather the state of knowledge of a certain group of individuals at a certain time. Acquisition of knowledge is defined as the work that advances the state of knowledge within some community of practice, no matter how broadly or narrowly that community may be defined.

Additionally, knowledge building within the school setting can be authentic in that knowledge is not supplied only by the teacher or scholar but is advanced by the knowledge of the classroom community, and this work is situated within a larger societal effort. Knowledge creating communities make sense in society since "people are not honored for what is in their minds but for the contributions they make to the organization's or community's knowledge" (p. 100).

Idea improvement.

The second theme of idea improvement is summarized as guiding the efforts of students and teacher where not only the generation of ideas is encouraged but also the sustained effort to improve on those generated ideas is encouraged and incorporated into a teaching practice. An educational program committed to idea improvement develops the working premise that

all ideas are improvable and that idea improvement is, in principle, an endless practice. Therefore, it is the role of the teacher to decide whether or not to continue with a particular line of knowledge-building or to shift to another by measuring the balance between whether the ideas are advancing or hindering the knowledge building. The authors state that electronic media may provide an environment for the continuity of idea improvement and may “help to bring school knowledge building into closer alignment with the way knowledge advances in the disciplines” (p. 104).

Knowledge of in contrast to knowledge about.

In the third theme, two broad types of knowledge, defined by Anderson (1980) as declarative and procedural, are extended to include not only knowledge *about* something but also knowledge *of* something. The example of skydiving is used to distinguish between the two. Knowledge about sky-diving would be the declarative knowledge that a person could recite when asked what he or she knows about skydiving. This knowledge would be procedural and could be represented adequately in an outline or a concept map. However, knowledge *of* skydiving would imply an ability to participate in the activity itself. This knowledge would be both procedural, knowing how to open the chute, and declarative, knowing the rules or

equipment characteristics. Knowledge *of* consists of not only knowledge that can be stated but also knowledge that is implicit or intuitive. Knowledge *of* is activated when a need for it is encountered in action. The authors state that knowledge *about* dominates our traditional teaching practices where it is found in textbooks and subject matter tests while knowledge *of* is generally neglected in current curricula. They continue to state that problem solving is the best way to acquire knowledge *of* since it connects procedural learning to conceptual understanding. Problem solving supports the premise of knowledge-building because students work with problems that result in a deep structural knowledge *of*.

Knowledge-building discourse.

According to the fourth theme, knowledge-building discourse aims to progress the state of knowledge and build on idea improvement. The authors define guidelines that distinguish this type of discourse from others arguing that it involves a commitment to progress knowledge or an idea, seek common understanding rather than agreement, and expands the base of accepted facts. Knowledge-building discourse in the classroom goes beyond argumentation and debate to focus on the progress towards deeper understanding and solutions to shared problems. Scardamalia and Bereiter's

(1991) study describes a common problem with group work in the classroom where less able or less aggressive students are sidelined from participating. However, they find computer environments provide opportunities and access for these students to have a voice, allowing higher levels of agency in their Zones of Proximal Development.

Constructive use of authoritative information.

In the fifth theme, knowledge-building allows students opportunities to make sense of information given by authorities. Since all types of knowledge, including expert knowledge, first-hand experience, and reports from secondary sources, contribute to knowledge-building discourse judging the validity of the information becomes a task of the community. Therefore, while most communities rely largely on information from content specialists, knowledge-building practices allow students opportunities to apply authoritative information to actual problem solving while also encouraging additional information, whether from other authorities or from personal experience.

Emergent understanding.

In this final theme, the authors agree with a frequently stated constructivist principle that all understandings are emergent. They expand

this principle in knowledge-building stating that the interactions of individual ideas generate more and new ideas. They continue to state that educators should recognize that ideas are real things that can interact with one another to create new and more complex ideas and stress the importance of instructional designs created to support this type of interaction. Finally, they recommend using computer environments that support and organize ideas and understandings to support knowledge-building.

Models for Online Questioning

Online access to collaboration outside of the classroom offers students opportunities to deepen their understanding of mathematical topics. Curtis and Lawson (2001) found that students will collaborate through online mediums particularly when using a discussion forum. This study focused mainly on the interactions between students who reflect a high level of agency in the collaboration and knowledge-building process. In the high school setting, students need teacher support to scaffold the learning process before they can ask questions that will allow them to take control over their own Zones of Proximal Development in knowledge-building. These types of questions are ones that arise from situational models of problem solving and are crafted by skilled teachers. Students advance their understanding when

questions are designed to ask for sufficient reasons, ask for similarities between cases, ask for alternative rules or generalizations, ask for predictions, reveal student misconceptions, and lead students into a contradiction. This type of inquiry shifts the primary focus of textbook learning to universal understanding through outside sources. Evidence indicates that children are capable of producing questions that facilitate inquiry and study, which also suggests that there is potential for students to assume a higher level of agency in their ZPDs (Scardamalia & Bereiter, 1991).

Collaborative Online Knowledge-Building and Peripheral Participation

Since collaborative knowledge-building requires students to discuss emergent ideas, a trusting community of learners is essential. To promote both an online environment of trust and opportunities for knowledge building, three stages of activities are suggested (Curtis & Lawson, 2001; Riel & Sparks, 2009). First stage activities involve community building in which students are prepared socially and emotionally for the highly collaborative learning critical for building norms of trust and respect. Second stage activities require students to work collaboratively online to complete difficult tasks where idea generating, risk taking and problem solving are key

components to success. The final activities are individual tasks in which students document their personal understandings.

Riel and Sparks (2009) explain that the careful blending of in-class instruction and online learning can benefit knowledge-building experiences. They suggest that these blended online and face-to-face formats should be designed to promote emergent ideas and intellectual discourse, concluding that “understanding how technology, knowledge, community, and identity intersect may help perfect collaborative knowledge building in the future” (p. 13). Similarly, Curtis and Lawson (2001) describe successful collaboration between students in an online college course over one semester. Results from this study show that the types of collaboration performed by students online mirrored many of the same behaviors observed in collaborative learning during face-to-face interactions. Both researchers suggest that knowledge building may occur in both face-to-face and online environments.

Lave and Wenger (1991) provide a model similar to knowledge-building called *situated learning* in which learning is seen not as the acquisition of knowledge by individuals but from social participation. Additionally, the nature of the situation in which learning occurs significantly impacts the process of learning. This model suggests that learning involves participation

in a community of practice where people learn at their periphery. As participants of the community become more competent, their participation becomes more complex and moves to the center of their particular community. Lave and Wenger's (1991) study of apprenticeships found that, "A person's intentions to learn are engaged and the meaning of learning is configured through the process of becoming a full participant in a sociocultural practice" (p. 29). Peripheral learning in a school environment suggests that students with more knowledge participate in more complex ways, while the participation of students with less knowledge is minimal until their knowledge base increases.

Conclusion

Although all diploma-bound students in California take Algebra 1 to graduate from high school, Chapter II clearly indicates that all students do not experience success. Gaps in algebraic achievement exist between African American, Latino, and White students as well as between disabled, ELL and socioeconomically disadvantaged students when compared to non-disabled, not socioeconomically disadvantaged, and English proficient students. Studies show that students experience improved mathematical performances and narrowing of this gap when student-centered curriculums are implemented

and when teachers and school staff provide supportive environments (Boaler & Staples, 2008; Gutierrez, 1999; Gutstein, 2007; McKinney et al., 2009; Slavin et al., 2009; Stewart & Foster, 2008; TIMSS, 1999).

Also, learning environments that are less teacher-controlled and more spontaneous facilitate greater student interest and conceptual learning than do environments that are teacher-directed and controlled (Deci & Ryan, 1987; Ryan & Deci, 2000). Students who are intrinsically motivated by relevant math develop greater conceptual understanding while at the same time, students who understand conceptually are motivated to learn more math. Students can also be extrinsically motivated through rewards to perform skills such as memorizing and applying formulas however, intrinsic motivation is needed to promote conceptual understanding.

Since intrinsically motivating activities that promote agency and choice contribute to better conceptual and procedural understanding, giving students a higher level of agency in their Zones of Proximal Development can positively contribute to knowledge-building. However, allowing students greater agency over their own ZPDs requires not only opening the classroom to students' questions, but also to provide a new structure to support students in a question-asking role and to provide a medium for idea generation and

emergent understanding. Learning communities allow students to participate peripherally while they develop greater understanding. Therefore, a learning community designed using knowledge-building principles that blends in-class instruction with online activities will likely support the learning of more students resulting in improved understanding and fluency in mathematics.

IV. Review of Existing Curricula

Many factors contribute to student success in mathematics such as motivation, engagement, understanding, relevance, and experiencing competency. Motivation, according to Deci (1995), requires understanding and confidence. To be engaged learners of mathematics, students must feel that the need *to know* is important. Freire (2008) contends that educators who are truly motivated to liberate students through education must reject the banking concept, or the transmission model of education, and replace it with problem posing education. In this setting, teachers become students and students become teachers and through mutual dialogue, students feel increasingly challenged and motivated to respond to problems that are relevant to their lives. Vygotsky (1978) theorized that all learning is social and that understanding and development occur through the collaboration with others. He described this process of conceptual development as a result of the collective experiences of a group of learners through problem solving and experimentation, and argued that in order for learning to be maximized, students must be in their Zones of Proximal Development. Van de Walle (2003) argued that mathematical competency requires both conceptual understanding and procedural fluency.

The goal of this project is to provide a social and culturally diverse environment conducive to student discourse and collaboration—one that motivates students to achieve mathematical competency through conceptual understanding and procedural fluency, not only in the classroom, but that can also be sustained at home via online access. Current curricula will be reviewed to address the theories stated above by examining each curriculum for its ability to sustain the described learning environment of discourse, collaboration, conceptual understanding, procedural fluency and motivation. The three curricula to be reviewed are widely used for Algebra 1 in the United States and adopted in California. Additionally, each is the current adoption at Southern Unified School District and Needmore High School.

California Algebra 1 by Prentice Hall

California Algebra 1 (Bellman et al., 2009) is a traditional textbook with eleven chapters each containing from five to eight lessons. Some lessons begin with an investigative activity where students systematically explore a concept or procedure. Approximately four examples model the topic presented in the lesson. These examples are often illustrated with graphs, tables, and/or pictures and could be helpful to parents at home when helping their children

complete home assignments. Each lesson is accompanied by approximately 70 exercise problems designed to promote procedural competency.

Discourse, collaboration, conceptual understanding and procedural fluency.

Even though some sections begin with an investigative activity, these problems are not designed with collaborative learning in mind nor do they promote student discussion or reflection. There are limited opportunities for students to talk, write, or reflect since critical thinking activities are minimal and generally only appear at the end of very long problem sets. Given the attention paid to procedural problems, those requiring critical thinking and interaction are most likely overlooked. In addition, there are no *messy* problems, ones that promote complex ideas and multiple solutions, and no long-term projects to motivate relevance. The problems are good for practicing procedures in isolation, but the program does not offer problems that require students to use multiple methods and approaches to solve and reflect on the process. A teacher who uses this book will need to design specific lessons to give students collaborative opportunities since they are not supported in either the text or the teacher resources.

California Algebra 1 (Bellman et al., 2009) provides very little opportunities for conceptual development and relies on independent modes of working since all the problems in the text can be done independently. The exercise problems in the book emphasize skills which are beneficial in developing procedural fluency and for independent practice. However, they do not promote conceptual understanding, nor do they allow students to work socially or to develop their Zones of Proximal Development. For ELL students, other than the online lessons in Spanish, this resource is not inviting since it is text dense and cluttered which makes accessing the content difficult.

Online Features.

California Algebra 1 offers many online support features. There are video tutors for both lesson demonstrations and homework help that demonstrate procedures. Some tutorials offer lessons in Spanish. The text also offers students online Vocabulary Quizzes, Lesson Quizzes and Chapter Tests. Additionally, the online teacher-support materials are extensive and with permissions, teachers may also access texts for 6th grade, Pre Algebra, Geometry and Algebra 2 as well as all the support materials from those courses including worksheets and test generators. The online capacities and support features comprise the strengths of this program. If students have

access at home, they do have multiple ways to see and experience the material.

Algebra Connections by College Preparatory Mathematics (CPM)

Algebra Connections (Dietiker & Baldinger, 2006) is not a traditional math book but incorporates investigative practices not generally included in curricula like *California Algebra 1*. Twelve chapters each contain two to four sections and the sections generally begin with one large investigative problem to activate prior knowledge and explore a new or emerging concept. Three to five additional problems then further develop students' conceptual understanding and the "Review and Preview" section that follows allows students to reinforce prior skills or to develop the skills in current topics. In total, there are approximately 20 problems per subsection. The textbook, however, is printed in only black and white and the pictures include graphics, like clipart and drawings, but not actual photos. Text is predominating on each page leaving little white space. This text-heavy presentation does not support the needs of some ELL students and is of limited visual interest to all learners.

Discourse, Collaboration, Conceptual Understanding and Procedural Fluency.

All CPM curricula rely on student collaboration and exploration to develop conceptual understanding. Students are expected to work in small groups, consisting of three or four students, and the program advocates that each student is specifically assigned a team role. Each section contains multistep problems that students must solve in collaboration promoting student discussions and incorporating prior knowledge and exploration. Students may find the investigative approach and open-ended problems interesting and engaging. However, without scaffolds and support, students generally do not have the motivation or skill competency to complete all the necessary steps for the concept to be fully understood or developed. In my experience, it is at this point that many students give up and become frustrated and more disengaged or disenchanted with mathematics.

While many of the problems are well designed to promote conceptual understanding, without modifications or extra supports, students rarely get to the “Aha!” stage in their development. If they follow the curriculum exactly as recommended, they are generally unable to make the connections that the authors intended and feel cheated out of real learning. This requires teachers

to either develop necessary scaffolds independently, or to receive additional support to scaffold learning so that students can make lasting connections.

Some district teachers abandon this textbook and program for more traditional means of instruction for this reason.

Finally, *Algebra Connection* offers minimal procedural practice and many times, subsections only develop a concept or procedure topically rather than deeply. It often takes several chapters of spiraling in order to reach the level of rigor required for state standards. And while spiraling can be an effective method of revisiting topics, students get frustrated when they are not able to make connections as to why they are doing what they are doing.

Online features.

No online activities, supports, or supplements accompany this curriculum. The only online reference is *hotmath.com* which provides solutions to selected problems.

Assessment and Learning in Knowledge Spaces (ALEKS)

ALEKS (UC Regents and ALEKS Corporation, 2009) is a web-based program designed to give students differentiated instruction in Algebra 1. The program claims to be an artificially intelligent assessment and learning system that is able to determine exactly what a student does or does not know

about mathematics. Students begin this course with an assessment to determine their skill level. Once skill level is determined, students are programmed into a learning mode that displays each particular area of study as portions of a pie chart.

Online features.

ALEKS is completely online. Students proceed through the content by choosing available topics from their pie chart. They are only allowed to choose topics that the program has deemed them ready for. Therefore, once a student's learning program has been established in this initial assessment, the only way learners can proceed through the course is to demonstrate mastery on enough practice problems which then prompts a new assessment. If they score sufficiently high on this new assessment, then more topics in the pie become available. However, if students get stuck in a particular area of study, they remain locked in until they learn the content well enough to test out of it, which may be for an undetermined amount of time. And when students get stuck, they are often unsupported since their classroom experience is not sociocultural, meaning that peer collaboration and dialogue among diverse learners is not used as an instructional practice.

Since this is a web-based program, students may work at home.

However, anyone can log in as that student and complete their problems when they work at home. Therefore, it is critical for the correct assessment of actual student knowledge, that students take all assessments in the direct supervision of the content instructor.

Discourse, collaboration, conceptual understanding and procedural fluency.

The learning environment for this program is not conducive to collaboration since students are expected to work independently on a computer program that was purchased for each specified student. Their role in the class is to sit alone at a computer and master the content standards. The lessons are interactive in that students will click on their pie chart to choose a topic, the computer will show a few examples of the procedures needed, and then students will perform a few practice problems that mimic the demonstrated examples. When students are correct in solving problems independently, they are prompted to new problems. If students' answers are incorrect, they are returned to the problem where the error is identified. If they solve enough problems in a topic correctly, they will be programmed to take an assessment. Students who pass the assessment move forward in their

pie topics while students who fail the assessment move back in their pie topics.

When used for remediation and support to an Algebra 1 class, *ALEKS* offers students plenty of procedural practice as well as differentiated learning based on need and pacing. However, as a standalone curriculum, *ALEKS* fails to meet the goals of a collaborative, reflective learning environment where students are encouraged to explore methods and to represent problems in multiple ways. Students are not given opportunities to develop conceptual understanding of the topics nor are they given peer interactions or hands-on solutions to problems that are relevant to their lives. One teacher from my school reported that students who cannot master a specific topic get bored because they get stuck repeating fractions, for example, which diminishes motivation. Two teachers from my school have claimed that this program is better suited for ELL students since it provides some support in Spanish and contains very few word problems. No data exists to support this claim and simply avoiding word problems deprives ELL students with the experience and the scaffolds that they need in order to successfully navigate context-based problems in future math classes. And while this program engages most

students initially, those who do not experience success or competency lack the motivation needed to make continued gains.

Conclusion

Reviews of the current approaches used for Algebra 1 at Needmore High School and at Southern Unified School District generally reveal that while *California Algebra 1* and *ALEKS* align to standards and offer online supports and procedural practice, they do not offer students collaborative, student-centered environments with conceptually rich activities. And while *Algebra Connections* offers conceptually rich activities and student-centered collaborative learning, it does not offer online practice or opportunities to develop procedural fluency. Therefore, none of the existing materials reviewed meet the needs of Algebra 1 students nor do they reflect the best research. Instead, this research calls for meeting Algebra 1 content standards through student-collaboration, reflective learning environments that enforce both conceptual and procedural fluency, and learning that occurs both in the classroom and at home.

For struggling students, the evidence of achievement gaps widening rather than narrowing remains a critical issue in equity. Therefore creating teaching practices that allow for various styles of learning is a necessary factor

in lesson design. In order for students to gain valuable practice and participation in learning activities designed to promote success, they must be motivated to engage in the first place. Cooper et al. (1998) show that completing homework has a positive effect on student achievement and indicates that homework activities need to be perceived as valuable to the student and reflect the learning that takes place in the classroom. Therefore, the focus of this curriculum project is to create meaningful homework activities that support and extend the sociocultural environment of the classroom and that appeal to student interest.

V. Google Your Math: Sustaining a Sociocultural Environment through Collaborative Online Participation in Algebra

Google Your Math extends the social element of student collaboration and dialogue used in the classroom to an interactive online environment where students participate in mathematical discussions and problem solving, with a focus on improving student participation in math activities at home, and on improving student academic performances in algebra. The curriculum creates a flexible learning environment that blends classroom instruction and online activities using Google Groups, a service from Google that supports discussions groups based on common interests, and Google Documents, a free, Web-based word processor, spreadsheet, presentation, form, and data storage service which allows users to create and edit documents online while collaborating in real-time with other users. The design of the Google curriculum is guided by knowledge building-principles, such as: knowledge is advanced in a community rather than in an individual, knowledge is advanced through the improvement of ideas, discourse is collaborative in problem solving and builds on idea improvement, and all understandings are emergent, meaning that the interaction of individual ideas generate more and new ideas.

The first goal of *Google Your Math* is to increase the number of students who complete homework by providing a non-traditional approach for homework participation. With traditional homework activities, students practice math in isolation by completing worksheets or bookwork. With Google activities, students stay connected through peer-interaction and teacher-supported online discussions and problem solving. An additional component of this goal is to examine the populations of students who participate in Google discussions and activities to determine whether or not *Google Your Math* is equitable for diverse student groups.

The second goal of *Google Your Math* is to determine the types of interactions that students exhibit when they participate in mathematical activities on Google. Online student discourse and collaboration is evidenced when students give and receive help, exchange resources, explain methods, clarify information, share knowledge with others, give and receive feedback, challenge each others' contributions leading to negotiation and resolution, and monitor peer efforts and contributions. Regular teacher monitoring maintains a safe learning environment and ensures proper online etiquette during mathematical interactions. Similarly, consistent teacher and peer feedback

provide support in knowledge-building practices guiding the direction of student discussions, and problem solving attempts.

The third goal of *Google Your Math* is to improve student academic understanding and performances in algebra. Growth is determined based on scores from pre and post-implementation assessments in which students demonstrate their procedural fluency and explain their conceptual understanding. An additional component to this third goal is to explore the impact Google has on documented achievement gaps in student mathematical performances.

Google activities are used to discuss math and build content knowledge during a five-week unit on polynomials in Algebra 1. According to California standards, polynomials are typically taught towards the end of the year for Algebra 1. Key components to instruction include explorative group instruction in class, collaborative project work, and prompts designed to continue student dialogue via online networking. Explorative learning offers students opportunities to collaboratively solve conceptual problems to develop and refine skill knowledge. Online networking, using Google web-based programs, allows students opportunities to post questions, post

solutions, respond to questions, and respond to solutions thus forming a cyber math community.

These curricular activities offer students multiple ways to demonstrate their understanding while providing valuable information to inform future instruction. During classroom instruction, students work in heterogeneous groups that are purposely designed to support students with IEPs and students who are not yet proficient in English language acquisition.

Classroom Instruction

Classroom instruction promotes conceptual understanding and procedural fluency through exploration and student discourse. Warm-up activities review previously learned topics in preparation for the daily lessons. Students work on the warm-up activity collaboratively in groups of four by asking questions, explaining, clarifying, and modeling. All students are welcome to demonstrate their solutions and methods to the warm-up problems even when several students want to solve the same problem. By allowing more than one student to solve problems, the class is exposed to multiple representations which are then examined and discussed in a whole-class format. Quiet and hesitant students who correctly solve warm-up problems use this opportunity to present their solutions on the board. These

actions encourage student participation, allow for different learning styles, and develop community trust in the classroom. It is important to nurture and maintain a safe classroom environment so that students model this behavior on Google activities at home.

New topics and concepts are introduced using inquiry and exploration where students consider and discuss answers in their groups. Generally, classroom instruction moves back and forth between direct instruction, guided discovery, and practice. In direct instruction, students take notes of new methods. In guided discovery, students participate in whole class questioning or group exploration in order to derive a procedure or understand a new concept. During practice, students work in their groups on problems to reinforce newly learned concepts or skills.

Google Online Learning Environment

Projects and discussion pages posted on Google Groups allow opportunities for mathematical learning outside of class. Students can use this forum to post progress, respond to surveys and prompts, ask questions, and reflect on problem-solving strategies. Additionally, students can report their individual and group progress while working at home on assignments they started in class. During implementation, six classroom computers are

available before school, during lunch, and after school for students without computer or online access at home. Computers in the media center and the community center across the street from NHS provide additional access.

Discussion prompts.

The weekly discussion prompts are designed using four knowledge-building principles: knowledge is advanced in a community, knowledge is advanced through idea improvement, discourse is used for collaborative problem-solving, and all understandings are emergent. The discussion forum is loosely-structured to allow emergent dialogue and student interaction away from class. Discussion pages include a place where students can give or receive help, explain methods, clarify information, share knowledge, ask questions, and monitor individual and group progress. Student participation posted on the Google Group is evaluated for mathematical discourse and peer collaboration using a coding schema described in Chapter VII (see Table 11). Participation in discussions is also evidenced by counting the number of individual student posts.

Group unit project.

Using the knowledge-building themes that knowledge is advanced in a community rather than in an individual, the unit project promotes group

participation and collaboration on Google Groups. This project, called *Box It Up*, involves finding the cardboard cost for several boxes of varying sizes by calculating the volume and the surface area as well as writing a generic equation which calculates the cost for any box. Students show all their work on a shared Google Document and Spreadsheet on which they submit their final solutions to their teacher. Google not only allows multiple members of the group to add and edit information from different locations, it also documents the progress of work done by the students.

Conclusion

Google Your Math is designed to provide opportunities for participation in mathematical discourse and collaboration in order to increase student understanding and performances in algebra. The evaluation of *Google Your Math* is designed to explore how students use Google in algebra and how Google affects their mathematical performances. *Google Your Math* incorporates collaborative learning, Google Groups, Google Documents, algebra tiles, and project-based instruction. A narrative of the implementation is provided in Chapter VI.

VI. Implementation and Revision of *Google Your Math*

I designed and implemented *Google Your Math* in two tenth-grade Algebra 1 classes. Students in these classes were repeating Algebra 1 after not earning a passing grade in their ninth-grade year. The class periods were 57 minutes long and met every day. The curriculum was implemented for five weeks and covered one unit in Algebra 1. The topic for this unit was polynomials and it covered two California Algebra 1 standards: A1 10 (to apply operations on polynomials) and A1 11 (to factor polynomials).

The Setting of *Google Your Math*

Needmore High School (NHS), with 2,628 students in grades nine through twelve, is the second largest comprehensive high school in a diverse inner-city southern California school district of over 220 schools. In 2008-2009, 41% of NHS students qualified for free and reduced lunch making NHS eligible to receive Title I funding. Many students come from bilingual families; however, the majority of the English Language Learners (ELLs) have a strong grasp on English as their second language. Small populations of NHS students reside out of the area and receive transportation services from the district. NHS is not a magnet school but has opened the door to students around the

county through different enrollment options offered through the district.

Table 2 shows the enrollment breakdown by ethnicity.

Table 2: NHS Enrollment by Ethnicity

Filipino	30.6%
White	19.0%
Latino	18.8%
Vietnamese	12.9%
African American	9.0%
Chinese	2.9%
Japanese	0.9%
Hmong	0.9%
Laotian	0.9%
Other Asian	0.9%
Cambodian	0.7%
Asian Indian	0.6%
Guamanian	0.6%
American Indian/Alaskan	0.4%
Korean	0.3%

NHS is a high-performing school in this district with an Annual Performance Index (API) of 802 in 2009. The API measures the academic performance and growth of schools and districts based on test scores. The State Board of Education set the statewide API standard at 800, which means that NHS meets the state standard. While meeting growth targets for API in the last three years, our school has failed to meet its Adequate Yearly Progress (APY) for the last two years. AYP is a measurement defined by the No Child Left Behind Act that allows the United States Department of Education to

determine performances on standards-based assessments for every public school and school district in California. The AYP goal for NHS was missed both years by the ELL subgroup population of students who are not testing proficient in English Language Arts. All other subgroups have met or exceeded goals for the last three years. Therefore, creating learning opportunities to support academic achievement for all students, including ELL students, remains a focus in curricula design.

Google Your Math was implemented in two Algebra 1 classrooms with a total of 39 students in both classes. The student populations were diverse in both learners and ethnicity. The classes were predominately male and there were overall, three learning rosters: students with disabilities (students with IEPs), English Language Learners (ELLs), and non-disabled, fully English proficient students (regular education). Table 3 shows student gender, Table 4 shows student ethnicity, and Table 5 shows student learning rosters.

Table 3: Classroom Enrollment by Gender

Gender	Total Students	Population %
Boys	27	69%
Girls	12	31%
Totals	39	100%

Table 4: Classroom Enrollment by Ethnicity

Ethnicity	Total Students	Population %
Latino	12	31%
African American	11	28%
Filipino	9	23%
White	7	18%
Totals	39	100%

Table 5: Classroom Enrollment by Learning Roster

Learning Roster	Total Students	Population %
Regular Education	21	54%
Students with IEPs	10	26%
ELLs	8	20%
Totals	39	100%

During this year, 20 students in the implementation classes were credit deficient meaning that while they were in their second year of high school, they were classified as ninth graders. All of my students were at risk for not meeting the state high school graduation requirements in math. Students are required to pass three math courses with a D or better. Since Algebra 1 is a prerequisite for promotion to subsequent courses, students need to pass this class as well as Geometry in their junior year, and Unifying Algebra/Geometry or Intermediate Algebra in their senior year.

Challenges specific to this learning community.

There were many student behaviors, learning disabilities, and conflicts which required careful consideration and constant monitoring in the two

classes where *Google Your Math* was implemented. Two boys in one class, Jamar and Angelo, had known affiliations to rival gangs. Both boys had been suspended from school for fighting, although they had not been in a fight with each other. Paying attention to their body language and words helped me to diffuse conflicts before they occurred or escalated. To promote their involvement in the learning community, I placed each boy in student groups where they were accepted and liked, and I worked to give them each a supporting role in the classroom.

Angelo was good at both math and conversational English even though he was classified as an ELL. He enjoyed working with Jose because Jose was also strong in math, yet Jose did not yet speak English. Angelo agreed to peer translate in his group because he could learn math from Jose and he could develop his ideas in Spanish. During the year, this group gradually spoke more English for basic communication, yet did most of their math talk in Spanish.

Jamar, on the other hand, was a low-skilled special education student who at almost 18 had earned a total of only five credits in four years of high school (students earn one credit for each semester class passed with a grade of D or higher). He liked to participate in whole-class discussions and to solve

problems in front of the class on the whiteboard. He also liked to work in his groups especially if he was able to represent the work of his peers to the entire class. In most cases, his work contained errors. It was challenging to keep him engaged in learning math rather than talking off topic.

Also in this class, there were only a total of five girls. Hudun, a native African ELL, was quiet and low skilled at the beginning of the year. Within the first month, she established a peer relationship with Shantice, an African-American student with a learning disability. The two of them worked exceptionally well together, although they needed extra help or guidance. Since their pairing sustained a continuously healthy growth, I kept Shantice and Hudun together whenever I changed students groups. Once I realized that Hudun was more vocal around female students, I placed the two of them in all girl groups for the remainder of the year.

In my other class, there were four boys who had been classified as having Attention Deficit Disorder. Because all four students were easily distracted and frequently off task, it was important that I did not place these boys near each other and at the same time, it was necessary to place them in groups with members who were more focused and on task.

Each of these student behaviors, personality, and performance challenges demanded my full attention and focus. They also made forming groups difficult with all the special considerations. I did my best to group students with at least one other student who they liked to work with and when possible, formed groups that supported first language discourse as needed. The diverse learning needs and student dynamics in these two implementation classes inspired the development of *Google Your Math* designed to promote learning math topics through online dialogue outside of class.

The Teacher

I have been a teacher of high school math for 15 years. My first seven years of teaching were in a small northern California district with only four schools. While teaching in northern California, I co-authored an Algebra 1 curriculum that was adopted and used in the district. This curriculum is used at my current school for our ninth grade algebra program and we have seen continued growth in student achievement on California Standardized Tests (CST) scores in mathematics over the last six years of implementation. When I came to NHS eight years ago, I was the only instructor to teach using student-centered activities where student learners worked collaboratively in groups.

For the last six years, I served as the department chair at NHS where I designed and facilitated regular professional development activities for the teachers in my department as well as create master schedules and attend instructional council meetings. Because of my dedication to curriculum development, the collaborative learning environment that I create, and the high achievement levels of my students, I was hired to work in the district's intern program teaching math pedagogy to first-year math teachers.

My classroom is a place where students think and talk about math. I purposely design lessons that promote student talk and collaboration. Teachers from other disciplines often walk by my classroom and peek inside because they are curious about how a math class can be run without a teacher always at the board and with the students working in groups. It is important to me that my students learn why the math works and not just how it works. My students will admit that I frequently report that I do not like memorized formulas. Instead, I teach students how to generate formulas through understanding.

Pre-implementation of Google Your Math

The implementation for *Google Your Math* began in March. Several pre-implementation activities needed to take place prior to working on the Google

Group. Readiness activities consisted of collaborative group work, reflective writing, obtaining online access, and learning to navigate the Google environment.

Fostering a collaborative learning environment.

In order to promote collaborative efforts and discourse in solving math problems, I fostered a safe learning environment starting on the first day of school in September using community-building activities. Students in my two implementation classes worked daily in groups of three or four except on days when they took an individual exam. Throughout the year, students worked collaboratively on math assignments by asking questions, discussing ideas, and explaining their understandings. To promote mathematical dialogue, I would pose a question or a problem for students to solve and I would write the following sentence frames on the board: "I think we should ____ because ____." Students effectively responded to this sentence frame by engaging in dialogue within their peer groups.

Occasionally, I placed the sentence frame on the board to generate dialogue. I told students that I was officially inviting them to talk about math. I continued to have students come to the board, show work and explain their steps. By the time of implementation of Google Your Math, students were

comfortable with working collaboratively in class on daily assignments and in group projects or assessments.

Preparing students to dialogue through reflective writing.

Since students would dialogue via writing in Google discussions, establishing norms in-class for written discourse was needed to prepare my students to write about mathematics. Therefore, the first lesson I presented for *Google Your Math* focused on reflective writing to explain mathematical procedures and concepts.

The lesson began with a warm-up activity which consisted of three problems taken from the released California High School Exit Exam (CAHSEE). Students working in groups received 15 minutes to complete and compare their solutions to the three problems shown in Figure 7.

1. An apple orchard packs apples in boxes that weigh 2 kg empty. The average apple weighs 0.25 kg. If a box of apples weighs 12 kg, how many apples are in the box?
2. John runs 4 miles per one hour. How long will it take for him to run 6 miles?
3. Solve for x : $5(2x + 3) - 4x < 12x - 9$

Figure 7: Warm-up Problems for Reflective Writing Activity

During the warm-up, I monitored the progress of student groups and listened to their conversations. Student discussion focused on the first

problem, particularly regarding the idea that four apples weigh one kg. When one group immediately answered that the box contained 48 apples and completely ignored the fact that the box weighs 2 kg, I told them to re-read the problem, and pointed out that they forgot to consider the weight of the box. For another group, I picked up a box and put in some pens. I said that the box and the pens had a total weight. Then I took out the pens and asked them if the box's weight was zero. When they responded that the box did not have a weight of zero, I redirected their discussion towards revising their solution.

I also monitored my ELLs to make sure that they were making meaning of the problems. Students are encouraged to speak in their first languages when needed since I believe that deeper mathematical comprehension takes place when students who are not proficient in English language can process information in their first languages. And finally, I asked student groups who were listening to others and comparing answers to make sure that they could explain their solutions.

When most groups had finished solving and discussing their solutions to the three problems, I announced to the class that since Nathan was absent, he had missed this lesson. So, to keep him informed on what we learned today, for the remainder of the class, we were going to write about these

problems by completely explaining their solutions on paper. I instructed students to take out paper and to choose one problem that they felt comfortable in explaining. I told students that they needed to write out the problem, solve each problem completely, and explain each step in words. To promote reflective writing, I asked two questions:

- 1) "Why do you think it is important to write out the problem?"
- 2) "If you were Nathan, what would you want know?"

I solicited student answers that indicated the importance for written clarity so that a student who was absent could understand the problem and its solution. Students chose one problem and worked individually on this assignment.

I decided to allow students to create their own class rubric for problem reflections rather than follow a teacher-made rubric. Now that students had completed the task of writing one reflection, they could negotiate, through a class discussion, the essential aspects of their rubric. When all students were finished, I wrote "Rubric" on the board. As a whole-class we determined four criteria necessary for a complete reflection: 1) Write out the problem; 2) Show the steps; 3) Explain each step in words; 4) Show the answer. Additionally, students decided that the reflection activity should be worth 10 points. So

again, through whole-class mediation and negotiation, the classes allocated point values for each criterion. Both classes placed higher point values on showing and explaining steps. Table 6 shows the rubrics generated in each class.

Table 6: Student Generated Rubric for Reflective Writing Activity

Criteria	Point Value (Period 2)	Point Value (Period 3)
Write out the problem	2	1
Show the steps	3	4
Explain each step in words	3	4
Show the answer	2	1

Students then used their class-generated rubric to grade their own reflections. This gave students practical application and reflection on their own writing. Some students were painfully honest and gave themselves grades that were lower than if I had graded them. When I collected their papers, I told my students that I appreciated their honesty and that they would be rewarded with full credit since they did not have the rubric before they wrote the paper. In closing, I added that reflective writing was necessary for participation on the Google Group that we were implementing in the upcoming unit.

I selected three samples, one from each problem, of reflections that had correct solutions and steps. I made copies of these samples and on the

following day, I gave these copies to Nathan, who was absent the day of the reflective writing activity. I reviewed both the assignment and the rubric with my students and we repeated this activity again the following day with three new problems taken from the CAHSEE. Figure 8 shows Tony's writing reflection of problem three which was one that I copied for Nathan.

each step and include a solution. Problem #3

Step 1
First, you write down the equation: $5(2x-3)-6x < 9$

Step 2
Second, you use the distributive property to get rid of the numbers in the parenthesis: $10x - 15 - 6x < 9$

Step 3
Third, you combine like terms: $4x - 15 < 9$

Step 4
Fourth, you add 15 to both sides to get the $4x$ by itself: $\frac{4x}{4} < \frac{24}{4}$

Step 5
Fifth, you divide four on each sides to solve for x : $x < 6$

Step 6
Sixth and last is your final answer: $x < 6$

Figure 8: Student Sample of Reflective Writing Activity

Preparing the Google Group.

I created a Google Group for each of my two periods (as detailed in the Teacher Lesson for *The Great Race* in the appendix). Classroom cohesion through peer familiarity was the reason for creating two separate groups. I wanted the environment to model the classroom, and I wanted students to feel safe to present their ideas, post work, ask questions, answer questions, and monitor their group's progress knowing that only the students in their class could access the Group. Additionally, I set the privacy settings to the highest possible setting allowing new membership by my invite only. I had obtained 30 email addresses two weeks prior to implementation. I invited these 30 students to their Group and continued my efforts to obtain email addresses for the remaining 9 students. Four of these students did not have an email address, so I helped them create a Gmail account in class prior to implementation. As I collected more email addresses, I added them to the group.

I presented the Google Group to both classes the week prior to implementation and asked students if they could try to sign in from home. I explained that if they did not have a Gmail or Google account, that they would have to create a new account using the email address that they had

given me. Unfortunately, we were in the middle of preparing and testing for the CAHSEE which limited my ability to work with individual students to login and access the Group prior to implementation.

Implementation of Google Your Math

I used *Google Your Math* during a unit on polynomials which is typically a topic covered later in the year. This unit lasted five weeks. Many activities in the unit required that students use Google in some capacity to obtain information regarding assignments, to work collaboratively on problem solving, to demonstrate their knowledge or understanding, or to dialogue on discussion pages. To launch *Google Your Math*, I created and implemented an interactive in-class activity called *The Great Race*.

Launching with *The Great Race*.

I designed *The Great Race* contest (included in Appendix) so that every student was able to login to our Google Group, and so that each student was able to navigate the Group using all its features such as, posting on a discussion, creating a page, discussing a page, downloading and uploading a file, and editing personal profiles. *The Great Race* also required that students create, share, and complete a math problem on Google Documents. This activity design allowed for a collaborative student-centered exploration rather

than a teacher-directed lesson. Launching with only one computer per group, *The Great Race* started our unit on polynomials.

On your mark.

Assembled in their new groups, I projected our Google Group to the class. I explained the directions for *The Great Race* and how their teams (groups) would compete against other teams for points. The goal, I announced, was to learn how to do specific tasks so that they could duplicate them at home. These tasks included logging in, navigating through the Group to find certain pages, members, and discussions, creating a page, participating in discussion, downloading a file from the Group, and finally—creating, editing, and sharing a Google Document. The contest was an assignment worth 10 points for each student with extra credit awarded to teams who finished first and second.

Get set.

The students were eager to begin and were already pointing to their desired computers. With the first set of clues stuffed and sealed in an envelope for each group, I instructed students that they needed to do exactly what was stated on each set of directions before receiving their next set. I purposely did not indicate how many clues existed so that students did not

know whether or not they were close to being finished. I handed one envelope to each group and we began.

Go!

And they were off! Students tore into their envelopes to read their first clue (included in the Appendix). In the first clue each group named their math team and then assigned each teammate to a specific gem: diamond, emerald, ruby, or topaz. Later in the implementation, I would assign specific work to members in each team based on their gem name. This first clue did not require students to leave their desks or to use Google, so all teams were able to quickly complete this step and receive their next clue.

During the second clue (included in the Appendix), several teams experienced problems. I sat in the front of my classroom logged into our Google Group so that I could verify the directions for each clue. The special education aide, Mr. Bayer, and student teacher, Ms. Hyple, stayed in the back to help students at the student computers. The trouble started when several teams that got stuck because a student from their team could not logon to Google.

I discovered that many students had not tried to login even though they had verified that they had received the invitation to the Group one week

earlier. And although I reminded students for several days prior to logging in, due to the CAHSEE, I was not able to see my students to verify that they were actually able to login. Since this clue stated that the person named Diamond needed to perform this set of tasks, if this person could not logon, then the entire group was held back.

In many cases, students needed to create new email addresses and then I needed to add them directly to the group because they were not successful in creating a Google account with the email they had previously given to me. There were also students who already had a Google account yet had forgotten their password so they could not login. And, there were still a few students who had not given me their email addresses due to absences. It was essential that I remained at my computer, as the administrator, so that students could come to me to add new addresses, to delete addresses that no longer worked, and to get help creating a new account. Additionally, I still needed to check out the teams who were able to logon and complete their tasks.

Another occurrence that I did not anticipate was that students who were creating an account through Google and logging in for the first time were sent a verification code either through voice mail or text. The first

student who raced up to me to ask me if he could use his cell phone to get a text was surprised when I said, "Of course," since cell phones were not allowed during class time. A few students did not have cell phones so Mr. Bayer and Ms. Hyple used their phones; however, this only helped some students since verification codes were sent to the same cell number only a limited amount of times. So, I got out my cell, and this business of verification and using cell phones continued well after the first two days of *The Great Race*. Even with these problems, several teams made it to the third clue (included in the Appendix) on the first day.

All-in-all, it was a productive first day even with the unexpected problems with logging in. There could easily have been chaos in the classroom. But surprisingly, students from both periods were actively engaged in helping their teammates complete their tasks even when they got stuck and they appeared to be enjoying this activity. As the Administrator, I enjoyed watching pages appear on the two Groups from my teacher computer. I was also amused and impressed by the clever names that my students had created. After the first day, Figure 9 shows the homepage for one class period.

Figure 9: Screen Shot of Homepage after the First Day of the Great Race

The finish.

We returned to *The Great Race* the next day and students continued logging in and proceeding through their clues. There were a total of five clues (included in the Appendix). During this 57 minute period, a total of four teams finished the race. Most teams made it to the fourth clue, except for The Mathletes and The Math Maniacs who did not get past the second clue due to login issues. We did return to *The Great Race* for a portion of a class period the following week so that more students could learn how to post on a discussion, create a page, download a page, and create and share a Google Document. The teams who finished the race worked in their groups on an assignment while I helped the remaining students to login. Again, I was pleasantly surprised by the good behavior exhibited by both students working either at their desks or on the computers, but I was disappointed by how much time it took to get every student logged into their Group.

Pre-assessing for prior knowledge and lesson design.

After two days of *The Great Race*, I was ready to begin teaching the content standard of multiplying polynomials. On the third day of implementation, 34 students took the pre-implementation assessment. I used the results from this assessment to learn information about students' prior

knowledge and skill levels for calculating areas, volumes, and for multiplying polynomials. The students' results from this assessment helped me to decide whether students needed conceptual development, procedural development or both. The first two problems involved computing volume and surface area for a rectangular prism. While these two problems are not directly related to Algebra 1 standards, they were necessary tasks for students to perform in order to complete the group project at the end of the unit. Both the third and fourth problems were standards-based. In problem three, students multiplied to find the product of $3x(4x^2 - 5x - 7)$ and in problem four, students multiplied to find the product of $(3x + 2)(4x^2 - 5x - 7)$.

For problem three, only four students correctly multiplied to obtain $12x^3 - 15x^2 - 21x$ even though eight students correctly explained how to perform the procedure to get a solution. Five students, who used distribution correctly, made errors in the exponents of x . The solution $12x^2 - 15x - 21$ is one example of this type of error.

For problem four, zero students correctly multiplied this product, three students correctly stated that they needed to use the distributive property and then add like terms, and twenty students left the problem blank.

Also helpful in determining student current understanding was a problem from the fourth clue of *The Great Race*. For this problem, students needed to simplify $(3x + 2)^2$ and explain their solution on a Google Document. All four teams who finished the race responded with similar yet wrong answers. Figure 10 represents two errors which were similarly found in other responses. The first error occurred when the team obtained a solution by only squaring the first term and the second term rather than using double distribution which would produce a third term. The second error occurs when the team squared $3x$ resulting in $9x$ rather than $9x^2$. The correct solution is $9x^2 + 12x + 4$; however, none of the four teams included the middle term of $12x$ in their solution.

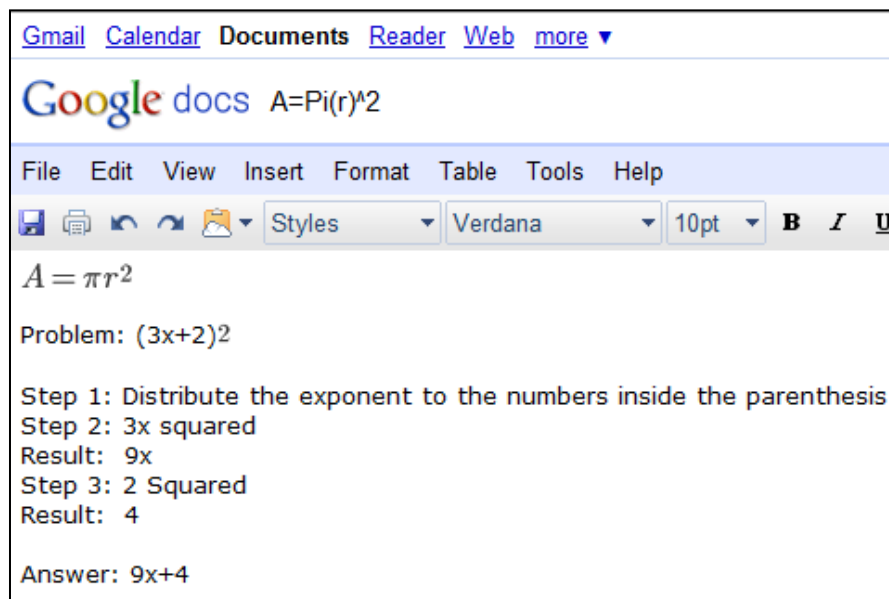


Figure 10: Team A = Pi(r)^2 Solution to Great Race Problem in Clue Four

The results from these three problems informed me that while my students had some understanding of the procedure for multiplying using the distributive property, they did not understand the following three concepts: 1) how the terms distributed, 2) how the variables with exponents were affected by the multiplication, and 3) that when a binomial is squared, there are three terms in the solution, not two. This indicated that students needed work building and understanding the math concepts as well as correctly applying the procedure. I decided to use area models and algebra tiles for class lessons where students could physically build rectangles to connect all three of these ideas conceptually. The curriculum included in the Appendix includes all the activities that were designed and revised for *Google Your Math* based on these results.

The discussion prompts.

While teaching algebra for 15 years, I have witnessed students making the same mistake—year after year—when squaring a binomial. Even advanced students try to take a short cut when multiplying $(3x + 2)^2$ by only squaring the first and second term. The benefit to using algebra tiles to build area models for multiplication is that students physically see that there exists a middle term. Students' misconceptions on *The Great Race* problem inspired

me to make my first discussion problem on Google Groups a conceptual problem rather than a procedural one which followed the knowledge building principal which states that all understandings are emergent. Figure 11 shows the first discussion prompt posted on the Google Group.

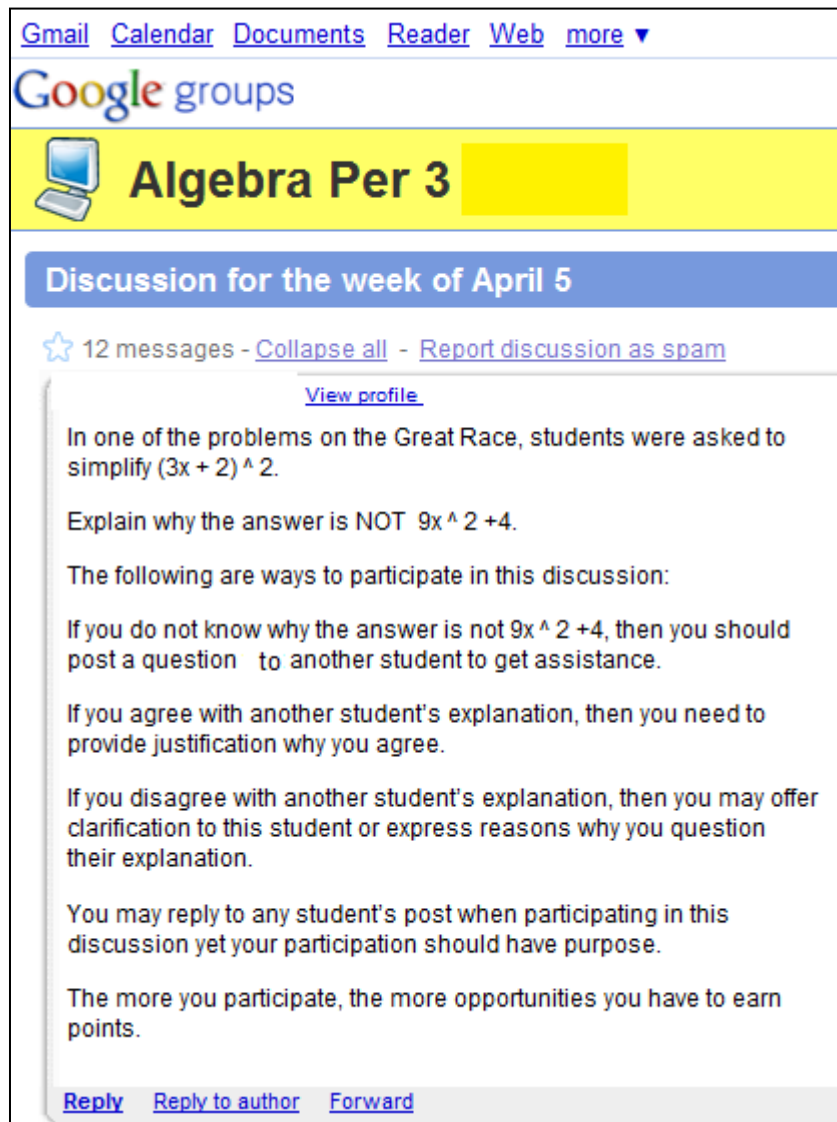


Figure 11: Screen Shot of Discussion One Prompt

Discussion One.

Since the week following *The Great Race* I was still working with individual students to solve login issues, I decided not to post the first discussion until the following Monday. So, for the first week of implementation, students worked in class with algebra tiles on curriculum that I developed called Patio Builders (included in the Appendix). The objectives of Patio Builders were to design patios in the shape of rectangles and to calculate the areas and perimeters of these patios and to determine the dimensions of length and width. In a later activity, students were given areas as polynomials and they built the patio rectangles using tiles to represent the area and then determined the dimensions

When the discussion was posted for the first time, I showed my students how to find the post and how to reply to it. I also read the post to them and indicated how they could earn points for their participation stating that a new discussion topic would begin every Monday. We spent a few minutes looking at the Google Group and the discussion in class and then I told them that they had until Sunday to post. I was anxious and excited to see how students responded to this prompt and I looked forward to reading and replying to their responses. Monday night, I checked the Groups every fifteen

minutes to see if any student had posted. No one did. On Tuesday, at the beginning of the period, I reminded students to participate and reminded them how to get points. Students seemed uninterested and I figured that this attitude had to do with the fact that they were not required to post until Sunday and that they might wait until Sunday to participate.

When Wednesday rolled around and still no one from either period had yet to respond, I worried that students were not going to participate at all. When I checked on the Groups late that night, I saw a post by Mr. Bayer: "A hint to solve the problem: What is the answer to $(5)^2$. Think about what that says to do. I hope this helps."

When there is a post on the Group, the members of the Group are notified by email. I thought that this might encourage students to participate. By the end of the evening, there were two students who replied to the email: Jamar and Sherwin. Jamar's first reply was an attempt at a solution however it was incorrect. His second reply indicated that he could not logon to the Group because he had forgotten his password. Sherwin also wrote that he could not login. Mr. Bayer responded to Jamar and Sherwin via email and I verified Mr. Bayer's response to Jamar through email also. This discussion is shown (in exact words used) in Table 7.

Table 7: Student Responses from Discussion One

Date	Posted by	Actual Posts
April 6 3:30pm	Mr. Bayer	A hint to solve the problem: What is the answer to $(5)^2$. Think about what that says to do. I hope this helps.
April 8:41pm	Jamar	$(3x+2)^2 = x=3$ see it wasnt the other answer becuz we didnt * it
April 6 8:44pm	Jamar	sorry i couldnt do the other one becuse i forgot my password we made in class so woulkd it be alright if i come in atr lucnh do them?? well you know where to get a hold of me so. more...
April 6 8:45pm	Mr. Bayer	Jamar, I do not understand your message/answer. Please clarify it for me and see what we have.
April 6 8:52pm	Mr. Bayer	Jamar, You have to get your password from Mrs. S. I imagine that this message was meant for her. Did you attempt to solve the problem? Try it on paper and lets see what you come up with in class tomorrow. $(3x + 2)^2$.
April 6 8:57pm	Jamar	How am I suppose to do that over the computer lolz but ill tryy!!
April 6 9:43pm	Sherwin	I cant log in
April 6 9:47	Mr. Bayer	Sherwin, I can't help you. You need to get password etc from Mrs. S. See you tomorrow in class.
April 6 10:26pm	Mrs. S	Jamar, I can help you tomorrow to get into the group. I appreciate your efforts.

On Thursday I decided take class time to work on posting to the group and problem-solving the remaining login issues which both Jamar and Sherwin pointed out. First, I printed out the prompt and gave it to the student teams in class and asked them to determine a team response. I then asked each group to pick a student to post their response under their team's name. My hope was that if students successfully posted on the Google Group in class with the support of their peers, that they would be more inclined or able to do it at home. Second, I worked with individual students to solve more login

problems. At the end of the class period, both Jamar and Sherwin were able to login to the Group, and a total of six teams posted from both classes. The continuation of Discussion One (from the teams, the individual students, and the teachers) from one class is listed in Table 8.

Table 8: Continued Dialogue on Discussion One

Date	Posted by	Actual Posts
April 7 9:10am	Jamar	LETS JUST SAY I DONT REALLY UNDERSTAND ANY OF THIS IM CONFUSED
April 7 10:26am	Angelo	response from math maniacs.....the answer for this problem is $9x^2+12x+4$
April 7 10:30am	Katie	response from the variable babes: the answer is not $9x^2$ because you can't make a full rectangle or square the correct answer is $9x^2+ 12x+ 4$
April 7 10:33am	Jorge	this is for team alpha pie $9x$ squared + $12x + 4$ count each one
April 7 8:22pm	Sherwin	response from slopes: If u lay out the tiles of $9x$ squared $2+4$, it doesnt make into a full rectangle the correct answer is $9x$ squared $2+ 12x+ 4$
April 8 8:10am	Abe	Sherwin thanks for posting that for our groups
April 8 9:15am	Mazen	$9x^2+ 12x+ 4$ because $9x^2$ its not a rectangle
April 9 12:07pm	Armando	those aswers helped me a lot thanks
April 9 10:13am	Mrs. S	Math maniacs, Thank you for submitting a solution, but can you explain how you got your solution? (any and all can respond from math maniacs)
Apr 10 5:43pm	Mrs. S	Armando, can you explain why these answers helped you a lot? What do you think the solution is and why? Why is the solution NOT $9x^2 + 4$?
Apr 10 3:35pm	Hudun	don't you distributed ? Anybody help!
Apr 10 5:37pm	Mrs. S	Hudun, Yes, distribution is the key to this process. However, when using distribution, you need to consider both dimensions. Try using the box method we learned in class on Thursday and Friday to set up the multiplication of $(3x + 2)(3x + 2)$. How does this answer compare to the one you got originally?

In the discussion represented in Table 8, three student teams posted during class and five individual students posted after class times.

Additionally, both Mr. Bayer and I offered feedback to students to support and guide student responses. Six of the posts offered solutions. Of those six, five solutions were correct and four provided explanations. And while not all students participated in this discussion individually, I was pleased with the way my students navigated the keyboard in order to represent mathematical equations, since Google is not user-friendly for equations and symbols. Also, this discussion showed me how my students were making sense of the concept of area tiles as they related to polynomial multiplication, which three posts referenced by making a rectangle. Additionally, noting the times of students' posts, I realized that students were accessing the Group at night, afterschool, during lunch, and during their second period class.

Discussion Two.

The second discussion prompted students to find the volume and the surface area of a rectangular prism with variable dimensions (included in the Appendix). I designed this discussion to prepare students for the rigor needed to complete the unit problem using knowledge-building discourse to collaboratively solve problems. However, this prompt proved difficult for

many students and only 10 students responded during the week. Only two of those students made correct progress through this problem and both students returned to work on the problem after I provided feedback on their work.

This was another eye-opener of the types of problems that students would try to solve. At the end of implementation, I realized that I should have added one more polynomial multiplication similar to those in the pre-assessment problems before posting this discussion problem.

What is a “Google”?

For students who expressed interest in finding new posts on Google, I posted an extra-credit prompt that asked students to define a “Google” (included in the Appendix). Since this was an extra-credit activity, I turned it into a contest in which students were required to email me responses rather than post them publically on the Google Group. Five bonus points were awarded to the first three students who correctly defined a Google (which is the number 10^{100}) and provided their source for the information. I wanted to see how students found the answer, whether it was to google “what is a Google”, or if they came up with different ideas. While two students gave an initial response that Google was a search engine, one student submitted another definition after my input that the answer I was looking for was related

to math. Out of these four students, two came up with the solution I desired and all four students posted online links for their citations.

Discussion Three.

Besides multiplying polynomials, the Patio Builder activities also developed concepts for factoring. I created the third prompt to explore methods for factoring (included in Appendix). The design of this prompt was inspired by the knowledge-building principle that knowledge is advanced in a community rather than in an individual and that knowledge is advanced through idea generation. My hopes were that students would work off each others' ideas in order to obtain a correct solution. I purposely created a difficult problem requiring many steps and only eleven students responded to this prompt during the week. However, I noticed that several students, who had not participated before, participated in this discussion. Additionally, five students returned to the prompt after teacher feedback to provide more information to advance the community knowledge.

My reasons for posting discussion problems with a higher level of rigor and that required multiple steps was for students to be able to read the work from other students as well as teacher feedback and then add to the dialogue and problem solving. If the problems were too easy to solve, then students

could just post answers after looking at the answers from the students who posted before them. If the problems were harder to solve, then students could look at the previous student work and the input from the teachers to find clues on how to build on that knowledge in order to come to the correct solution. And while these two problems were difficult, they did serve my intended purpose of providing students with multiple opportunities to participate on the same problem. During this week, no student posted a correct solution although several tried different times. In Discussion Four, I offered students the chance to continue working on this prompt and at that time, one student finally posted the correct solution.

Mid-implementation student survey.

After three discussion activities, I noticed that 17 students were not participating in the Google discussion activities. And while there were six computers available for students to use before, during, or after school, I was concerned that the lack of a computer at home might be limiting students' participation. To explore reasons for student participation (or lack of participation), I designed and implemented a personalized survey that specifically targeted three types of student participation. For students who participated on Google discussions more than two times, I asked, "Explain the

reason you participate in the discussions.” For students who participated one or two times, I asked, “Explain how you could improve your participation on Google discussions.” And for students who did not participate, I asked, “Explain the reasons you did not participate on Google discussions.”

Since these were open-ended responses, I looked for words or phrases to best describe their results. I was particularly interested in the reasons of non-participation for the 17 students who did not participate in order evaluate potential equity issues and to provide support, if possible, for future participation. These 17 students’ responses are summarized in Table 9 along with a few examples of student responses for the other two levels of participation.

Table 9: Student Responses to Mid-Implementation Survey

Participation	Reasons
More than 2 posts <i>“Explain the reason you participate on Google discussions.”</i>	<ul style="list-style-type: none"> • Because you get help if you get the wrong answer • I work better with students, rather than single at home • Because I want a good grade in the class • To figure out what we need help with and what we need to learn
1-2 posts <i>“Explain how you could improve your participation.”</i>	<ul style="list-style-type: none"> • If I can get on Google Groups more at home • Going on and answering posts • Ask for help • I do not have internet connection
0 posts <i>“Explain the reasons you did not participate on Google discussions.”</i>	<ul style="list-style-type: none"> • No computer or Internet access at home (6 students) • Did not know how to do Google (4 students) • Did not want to (1); No time (3); Forgot (1) • Lazy (1); Wasn’t online (1)

The student responses indicated that only six of the 17 students who had not participated gave the reason as not having a computer. Additional survey questions asked students how I could help with their participation and whether or not any student wanted to participate on paper rather than online. In order for their paper participation to be considered dialogue, I stated that I would post their written responses on a wall and as an activity in class each week, we would reply to the posted responses. The majority of students responded that I could help them by reviewing in class how to access the Group. Additionally, 11 of the 17 students responded that they wanted to reply to the discussions on paper while six stated that they wanted to use Google to respond. The following day I conducted a lesson that reviewed getting to the Google site and logging in, locating the Google Group, locating previous and past discussion topics, and demonstrating how to reply to a topic by responding to the current discussion activity.

Discussion Four.

For this discussion on Polynomials, I did not create a new post but instead allowed students to choose between four options (included in the Appendix): 1) Continue working on the problem from Discussion Three; 2) Create a discussion based on a problem they may have encountered while

working on the unit project; 3) Create a discussion based on the in-class assignments; 4) Participate in any mathematical discussion that has been started so far. In addition to these four options, I also offered students extra credit if they posted a factoring problem for students to solve, and they were required to monitor their problem providing peer-feedback.

The design of this discussion prompt was inspired by motivation theories which suggest that student choice and flexibility promote intrinsic motivation which can then lead to greater conceptual understanding. By giving students several options, they could participate at different capacities according to their comfort levels. Also, offering students the option of creating and monitoring their own problem allowed students to feel ownership in the Group since they could post problems of their creation. To accommodate students who requested hard copies in the mid-implementation survey, I provided 11 students with copies of Discussions One, Two, and Three.

In this week's responses, five students worked on the previous prompt and one solved it; four students posted their own problem to solve and monitored other students' responses with one student-created problem generating 10 student responses. Ethan, a student with an IEP who had

created his own problem and discussion page, excitedly entered class the following day asking, "Did you get my post?"

"Yes," I replied, "Did you get mine?"

We talked for a few minutes about his problem and then all of a sudden he came to this realization, "So, I can make like a lot of points if I keep on posting on the Group?" And, when I confirmed that the more he posted, the more points he earned; he responded, "Wow. I never thought of that!"

During this week, I received the following post from Nathan, another student with an IEP, "what i got for this problem was $3x(15x^2+16x-7)$ but i wasent so shore about putting them into the x thing because i got -105 on the top and 16 buttom but i dont know what gose into 105." Nathan demonstrated a good attempt at solving this problem. He found the greatest common factor, and he knew to use the x-factor, "x thing." He also indicated that 16 went on the bottom of the x-factor and that he knew that he needed to find factors of 105. However, his spelling and grammar may have distracted other students from reading his post. I wanted students to use reflective dialogue with flexibility, but I also wanted to encourage academic language skills in this environment.

Therefore, the next day in class, I showed students how to type a response using a Word Document and then how to run a spell check. I also showed them how to cut and paste their text into the Google discussion. I assured the class that they were not graded on their spelling and grammar, but on their ability to communicate the math. And while I wanted to provide students with a way to work on their sentence mechanics, I did not want to shut down students from participation due to grammar and spelling. Due to this, I was careful to not use or indicate any student postings as a reference while demonstrating the use of Word Document.

Incidentally, Evan responded to Nathan's post five days later reporting the correct factors to use in the x-factor to be 21 and 5. Nathan returned to the group the same day and offered a new solution. However, while he still did not have the correct solution, he did use the factors that Evan had provided.

During this week, we had begun to work on the unit project, *Box It Up*, in class. The unit project completed this unit and Discussion Four was the last prompt included in the implementation. Additionally, the 11 students who received paper prompts and the six who indicated that they wanted to participation on Google still remained non-participating.

***Box It Up* unit project.**

When the in-class lessons to support student learning for polynomial multiplication and factoring were complete, students started work on the unit project named, *Box It Up* (included in the Appendix). The majority of the work for this project was done in class and it was assigned to student groups. Each group's task was to calculate volumes and surface areas for boxes with varying dimensions and to find the cost per unit for cardboard for each box design.

I scaffolded the work on the unit project with the *Box It Up* activity (included in the Appendix) in which students rolled a die to determine the width of their box and then followed the guidelines from the *Box it Up* Project to determine the length and the height. The worksheet for this activity contained a graphic organizer to help students work through the procedures needed in the unit project. Additionally, student groups were given a planning sheet (included in the Appendix) to help them meet the deadlines.

While the project was initially designed for students to complete at home collaborating on a Google Document, I decided that the support and structure of the classroom environment was needed for students to be successful. Students were given three days in class to complete the dice

rolling activity, to divide the project tasks between all group members, and to calculate and report what they had completed. During this time, I helped each group create a shared Google Spreadsheet using the six student computers in the classroom. Students' tasks at home (or during lunch or after school) were to post their work onto their group's spreadsheet. Students were given four days, Thursday – Sunday, to post all their information online and on time.

On the Sunday that the project was due, I checked Google Spreadsheet several times during the day to witness student progress. And one time, I found two students, Alejandro and Art working on the spreadsheet at the same time and they were communicating with each other in the body of their Google Spreadsheet. Alejandro had posted, "COME ON LETS GET THIS DONE." And Art replied, "*sigh* okay Alejandro(art)." I noticed that while Alejandro and Art were completing their portions of the project, that there was no work from Antonio, the third student in the group. Amused by Alejandro's comment, I initiated the chat function in the spreadsheet and asked if they knew how to get in contact with Antonio so that he could contribute his part. Figure 12 shows the dialogue of this chat.

me: you tell them alejandro! Art, do you have a way to get a hold of Antonio so he can do his part?

alexjgon: Art do you know what to do?

asmith32sd: What the heck its magic

alexjgon: yeaah.

asmith32sd: Lets hack into anthonys sike Just kidding

alexjgon: there WOW dont. find the costs

asmith32sd: "Dont" isn't a word

alexjgon: gogoogogog hurry art

asmith32sd: mosue wont work

alexjgon: serious..

asmith32sd: I fixed it get on myspace im now? hello? you there?

me: hello!

alexjgon: hello there!

Figure 12: Teacher Initiated Chat with Students Working on Google

Again I noticed that the online language used by my students was less than academic. In today's culture of texting, IM-ing, MySpace, and Twitter, quick keying has become a valued skill. Unfortunately, I believe that this may have limited my students' desire to take the time to check their spelling and grammar. However, the goal of this curriculum was to express mathematical ideas through written dialogue. Perhaps future implementations will incorporate components specifically designed to support the use of academic language.

At the project's close, only 16 students completed all of the required tasks and posted their work on the shared Google Spreadsheet. However,

four students who had never participated in the Google discussion activities did complete this work and therefore experienced some of the collaborative features of Google's online environment.

Conclusion

At the unit project's end, I gave students the post-implementation assessment (included in the Appendix); the results are summarized in detail in the following chapter. I enjoyed exploring Google's instructional capacities in this curriculum design. I also found Google's environment flexible enough to use in other classes and with different topics. This curriculum might be more successful in classrooms that support one working computer for each student. However, the focused objective of engaging students at home in math dialogue would then be somewhat diminished.

With goals to increase students' homework participation, understanding, and mathematical achievements, as well as to provide equitable instructional practices for more students, I found *Google Your Math* addressed each goal with success. Chapter VII provides evidence that more students practiced algebra at home, felt supported and encouraged by peer and teacher feedback, and increased their mathematical performances in algebra.

VII. Evaluation and Assessment of *Google Your Math*

I designed *Google Your Math* to increase both student involvement in math related activities at home and to provide instructional practices that increased student performances in math. While I was interested in engaging more students at home in math activities, I was particularly interested in the rates of participation from different student populations in order to evaluate if Google activities were equitable for my students. I was also interested in the types of online interactions that students exhibited when they participated in order to evaluate whether or not Google discussions were a collaborative and reflective environment for learning algebra. And finally, I was interested in student performances in algebra in order to evaluate whether or not Google activities helped to increase student achievement while also narrowing achievement gaps among student populations.

To evaluate my project design, I tabulated the overall student participation on Google discussion activities. Next, the student interactions during their participation on Google discussions were coded using a coding schema (see Table 11) to categorize student interactions for collaborative math dialogue. Pre and post-implementation assessments to were used to evaluate student performances for both conceptual

understanding and procedural fluency (using a 2-point self-designed rubric shown in Table 13). And finally, I used both mid and post-implementation surveys to report student perceptions and to explain observed trends in more detail.

Evidence of Online Participation on Google

To document student participation on Google Groups, I recorded the number of posts made by each student during the implementation period. I was interested in whether or not students would participate in the Google discussions at home more than they completed traditional homework methods of worksheets and bookwork. And since my population characteristics were diverse, I was interested in whether or not all populations engaged in Google activities equally, since a driving force in my project design was to provide a collaborative and reflective learning environment that was equitable for all student populations. The following section reports and discusses the rates of student participation in Google activities addressing my interests in student participation and equitable access.

Findings for increased practice at home due to online participation.

During the five week implementation period, 22 out of 39 students (56%) participated in Google discussions. Prior to *Google Your Math*, only

seven out of 39 students (18%) regularly turned in homework during the year. Additionally, of those seven students, six participated in Google discussion activities. Since 22 students participated in Google discussion activities, this meant that 16 more students were practicing algebra at home than they had prior to *Google Your Math*. Yet, there still remained another 17 students (44%) who still were not practicing algebra at home. A primary concern that I had regarding participation was computer access at home. The mid-implementation survey indicated that out of these 17 students, only six reported not having a computer as a reason for not participating on Google discussion activities. One additional student reported that he did not have a computer but he used the computers at school to participate. Additionally, 11 out of the 17 non-participating students requested hard copies for discussion prompts. However, after providing 11 hard copies for the next discussion, none of the 17 students participated in any capacity, whether on Google or on paper.

Discussion of the findings for increased practice at home due to online participation.

When my intervention attempts for the 17 non-participating students were not successful, and my data continued to show the same results (the

same students continuing to post), I felt comfortable ending my data collection at the end of the five week polynomial unit. Overall, the participation results indicated that students were more likely to participate in Google activities than on traditional homework. With 16 more students practicing algebra using Google discussions (an increase of 41%), my next questions explored the populations of students who participated, and whether or not using Google activities had any influence on student performances in algebra.

Findings for online participation and student populations.

My two implementation classes had three learning rosters which included 10 students with disabilities (IEPs), eight English language learners (ELLs), and 21 non-disabled and fully English proficient students. Equally diverse were my students' ethnicity with 12 Latino students, 11 African American students, nine Filipino students, and seven White students. In exploring whether or not *Google Your Math* provided equitable access, the number of student posts from each population was counted. The rates of participation, which represented the number of students who posted on Google and not the number of posts made by each student, are shown first by learning roster in Figure 13, and then by ethnicity in Figure 14.

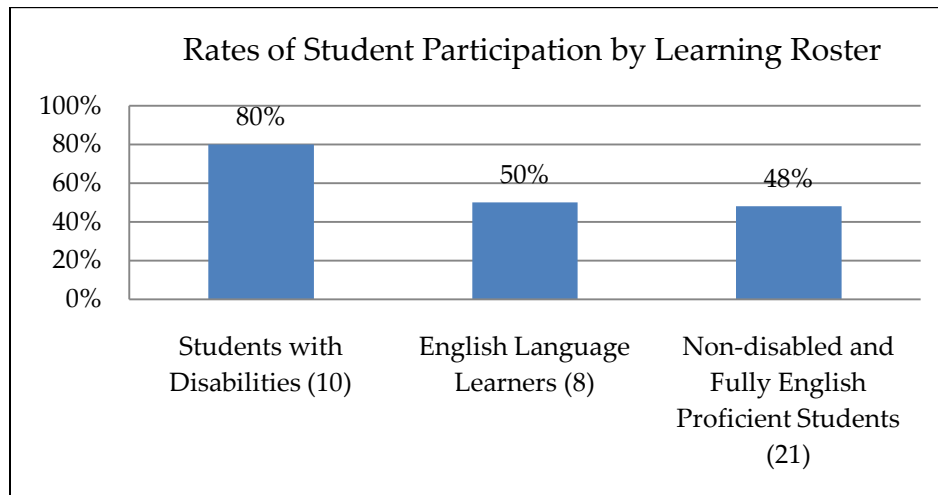


Figure 13: Rates of Student Participation on Google by Learning Roster

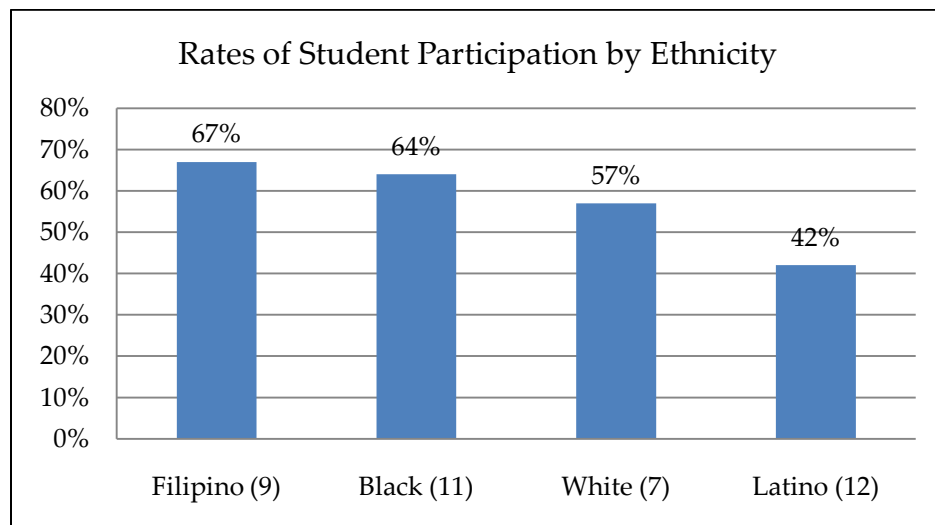


Figure 14: Rates of Student Participation on Google by Ethnicity

Discussion of the findings for online participation and student populations.

Although there is representation of student participation from all three rosters and from all ethnicities in my two classes, not all student populations

posted on Google equally. Students with IEPs showed the most online participation with 8 out of 10 or 80% of the students posting on Google Groups. The regular education students showed the least online participation with 10 out of 21 or 48% of the students posting on Google Groups, and four out of eight ELL students participated resulting in 50% of the students posting on Google.

Survey results reported seven students did not have a computer or Internet access as a reason for non-participation. Although students were allowed to use the classroom computers during lunch and afterschool during the implementation period, none of the seven students used them in order to participate. Table 10 shows the students who reported not having a computer as a reason for not participating. The Latino student population appeared to be at the biggest disadvantage which may explain this population's lower participation.

Table 10: Students Who Reported Not Having Computer Access

	IEP n = 10	ELL n = 8	REG n = 21	Totals n = 39
Latino	0	1	2	3
African American	1	0	0	1
Filipino	1	0	2	2
Totals	2	1	4	7

Evidence for Online Interactions on Google Groups

While the findings and discussion from the last section focused on participation, this section focuses on the types of online interactions made by students during their participation on Google discussion activities. In creating a collaborative-online environment, my goal was for students to interact regarding algebraic topics rather than to interact socially. Curtis and Lawson (2001) determined that student behaviors associated with collaborative learning activities can be identified in their online interactions. Using an adapted coding schema from the Curtis and Lawson (2001) study, I was able to describe the student online behavior during the activities designed for Google Your Math.

The coding schema is described in Table 11 with examples to support each type of behavior. The codes are categorized as planning, contributing, seeking input, reflecting and monitoring, and social interaction. Each category is further defined individually such as SK for sharing knowledge and HeS for help seeking. I made slight modifications in the Example section so that it better described the types of behaviors that my students might use in the activities that I designed. I also added an additional code, PC, to describe a declaration made by students regarding their perceived competency.

Table 11: Coding Online Behaviors adapted from Curtis and Lawson (2001)

Behavior Categories	Codes	Description	Example
Planning	OW	Organizing work: Planning group work: setting shared tasks and deadlines.	Let's divide the work this way so that it is fair.
	IA	Initiating activities: Setting up activities such as work times.	Everyone post by Friday at 7:00 pm so that we can edit.
Contributing	HeG	Help giving: Responding to questions and requests from others.	To get to Google Docs, go to..., click on..., etc
	FBG	Feedback giving: Providing feedback on proposals from others.	I like your idea of...
	RI	Exchanging resources and information to assist other class members.	Page __, shows how to use factoring.
	SK	Sharing knowledge: Sharing existing knowledge and information with others.	I think the way to do this is _____.
	Ch	Challenging others: Challenging the contributions of other members and seeking to engage in debate.	I posted this problem. Can you solve it?
	Ex	Explaining or elaborating: Supporting one's own position (possibly following a challenge)	I found my solution by____
Seeking Input	HeS	Help seeking: Seeking help from others.	Does anyone know how to ...?
	FBS	Feedback seeking: Seeking feedback before moving forward.	Can someone check my work before I move on?
	Ef	Advocating effort: Encouraging participation from others.	Can someone contact (name) to make sure he posts his work on time?
Reflection Monitoring	ME	Monitoring peer effort: Comments about classmate's process and achievements	Good progress but you still need to ...
	PC	Perceived Competency: Statements relating levels of student's own perceived competency.	I get this...I don't know how to do this...
Social Interaction	SI	Social Interaction: Conversation unrelated to group math talk.	This weekend I am visiting my friend...

Findings for online interactions.

When designing the prompts and activities for *Google Your Math*, I was interested in creating an environment where students could talk about math and collaborate. I also wanted students to feel supported and encouraged to engage in math activities at home. The purpose of this online environment was to build on and to support the class activities dealing with polynomial multiplication and factoring. It was my desire that students would use Google discussion activities to practice their algebraic reasoning and collaborative skills online. After coding each student post on Google Groups (using the coding schema from Table 11), it was determined that 95% of the interactions focused on mathematical content with only 5% social interactions. Table 12 reports the categorized student posts at the end of implementation.

Table 12: Coded Student Online Behavior

Behavior categories	Code	IEP	ELL	REG	Total	Code percent	Category percent
Planning	OW	0	0	0	0	0%	0%
	IA	0	0	0	0	0%	
Contributing	HeG	0	0	1	1	1%	71%
	FBG	3	0	1	4	5%	
	RI	0	0	0	0	0%	
	SK	16	8	19	43	54%	
	Ch	1	1	1	3	4%	
	Ex	1	0	5	6	8%	
Seeking Input	HeS	6	0	4	10	13%	15%
	FBS	0	1	1	2	3%	
	Ef	0	0	0	0	0%	
Reflection/ Monitoring	ME	2	0	0	2	3%	9%
	PC	4	1	0	5	6%	
Social Interaction	SI	3	0	1	4	5%	5%
Post Totals		36	11	33	80		
		45%	14%	41%			100%
Participating Students		8	4	10			
Average Post		4.5	2.8	3.3			
Median Post		4	2	2.5			
Mode		9 Abe	6 Mazen	10 Sherwin			

Discussion of the findings for online interactions.

The data for interaction indicated that students used the discussions more for mathematical discourse with the highest posting of 54% coded as shared knowledge. Additionally, 71% of the posts were considered contributions to the knowledge of the group which is more than four times higher than the percentages for the other categories. With the nearly three-fourths of all posts in the Contributions category, I was able to determine that

student did use Google Groups for collaboration. And while I was hoping that students would use the Group to plan their group activities while at home, there was no evidence of student planning on Google.

An additional finding showed that students with IEPs contributed 45% of all the posts made which is slightly higher than the regular education students who made a total 41% of the posts and considerably higher than ELL students who only made 14% of the total posts. When the total number of posts made in each learning category was divided by the total number of students who participated in the discussions, an average post per student was identified. The calculations showed that 4.5 average posts were made by students with IEPs, 2.8 average posts were made by ELLs, and 3.3 average posts were made by regular education students (shown in Table 10).

In two of the three categories, an outlier existed, which meant that one student posted significantly more than other students in that category. To calculate for outliers, the interquartile range was multiplied by 1.5, and the result was added to the third quartile which identified the mode posts of 9 and 10 to be outliers. While the mean is affected by an outlier, the median is not. Therefore to adjust for these students who posted more than others, I also reported the median posts of 4 for students with IEPs, 2 for ELLs, and 2.5 for

regular education students. Even without the outliers, this data consistently agreed with the findings from the previous section which indicated that students with IEPs posted on Google Groups more than any other student population, and they made more posts when compared to other populations.

Evidence for Student Performances in Algebra 1

I designed a pre and post-implementation assessment to evaluate student conceptual understanding and procedural fluency which were both measured on separate rubrics using a self-created 2-point scale shown in Table 13. The skills evaluated on the implementation assessments were calculating volume and surface area and multiplying polynomials.

Table 13: Rubric for Conceptual Understanding and Procedural Fluency

Conceptual Understanding	0 points – no explanation 1 point – explained an incorrect process 2 points – explained a correct process
Procedural Fluency	0 points – did not try or used an incorrect procedure 1 point – used a correct procedure but made errors 2 points – used a correct procedure with accuracy

Findings for student performances.

After five weeks of in class lessons, discussions, and the completion of the unit project, students took a post-implementation test which measured both procedural fluency and conceptual understanding. The test consisted of

four problems which were evaluated individually. Comparing the results to the pre-implementation assessment using the same problems and the same rubric determined that students improved both their procedural fluency and their conceptual understanding for all four problems. The first problem was a simple calculation of volume for a rectangular prism. The second problem was the calculation of surface area for the same rectangular prism. The third problem was to find the product of a monomial, and the fourth problem was to find the product of a binomial and a trinomial with each problem increasing in difficulty and rigor. The mean performance score for each problem looking at both procedural fluency and conceptual understanding is shown in Table 14.

Table 14: Polynomial Pre and Post Assessment Results
With 2 Being the Highest Score Possible

		Problem 1	Problem 2	Problem 3	Problem 4
Procedural Fluency	Pre-Test	1.1	0.5	0.6	0.1
	Post-Test	1.9 (+0.8)	1.1 (+0.6)	1.4 (+0.8)	1.1 (+1.0)
Conceptual Understanding	Pre-Test	0.9	0.5	0.6	0.2
	Post-Test	1.8 (+0.9)	1.2 (+0.7)	1.5 (+0.9)	1.4 (+1.2)

Student performances improved in both categories for all problems with the most growth found in Problem Four. Since Problem Four had the highest difficulty and was the most related to the exit-level skills needed for Algebra 1 standard 10, the number of 0's, 1's, and 2's for both pre and post-

implementation assessments were compared for each student. Figure 15 compares students' pre and post-implementation assessment scores for Problem Four on procedural fluency while Figure 16 compares students' pre and post-implementation assessment scores for Problem Four for conceptual understanding.

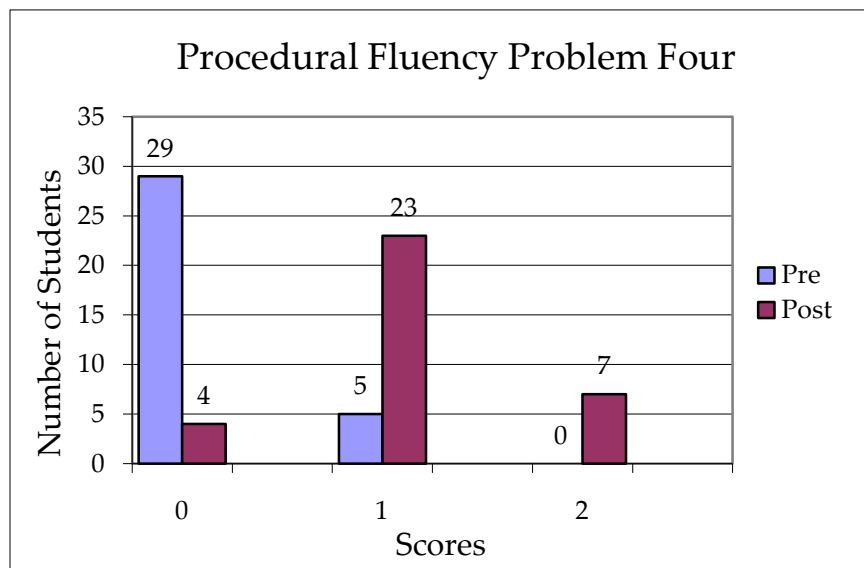


Figure 15: Procedural Fluency Pre and Post Assessment Score
With 2 Being the Highest Score Possible

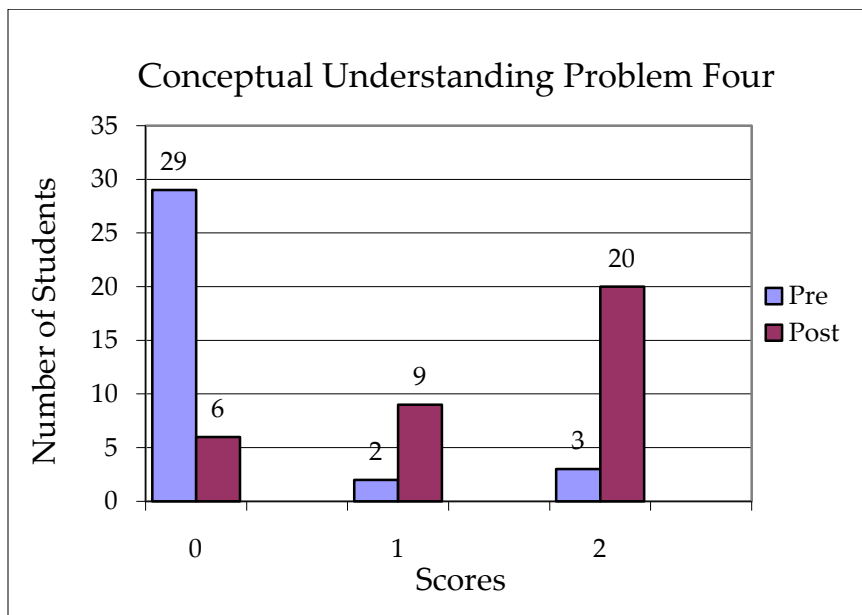


Figure 16: Conceptual Understanding Pre and Post Assessment Score
With 2 Being the Highest Score Possible

Discussion of the finding for student performances.

When looked at separately, the improvement for Problem Four in both conceptual understanding and procedural fluency is obvious. Prior to Google Your Math, 29 students did not know the procedures for multiplying polynomials nor did they understand the concepts of polynomial multiplication. After the classroom activities and discussion prompts, 20 students understood the problem conceptually while seven students could complete the procedure accurately. However, 23 students were able to apply the correct procedure even though they made minor errors.

Findings for closing achievement gaps in student performance.

Google Your Math was inspired by the need to provide equitable access of algebra to more student populations and to narrow achievement gaps in academic performances. In order to evaluate this goal, student performances for the California High School Exit Exam (CAHSEE), which students took the day before implementation of *Google Your Math*, were compared to student performances on the post-implementation Problem Four assessment.

Figure 17 shows that 90% of the students who were non-disabled and English proficient passed the CAHSEE while only 20% of students with disabilities and 38% ELLs passed. Additionally, Figure 18 shows that while 100% of the White and 78% of the Filipino students passed the CAHSEE, only 50% of the Latino and 27% of the African American students passed. Included in Figures 17 and 18 are the achievement scores for Problem Four post-implementation assessment. The scores for Problem Four illustrate performance differences for student populations and are compared with student performances on the CAHSEE in order to determine the degree to which achievement gaps exist on the post-implementation assessment.

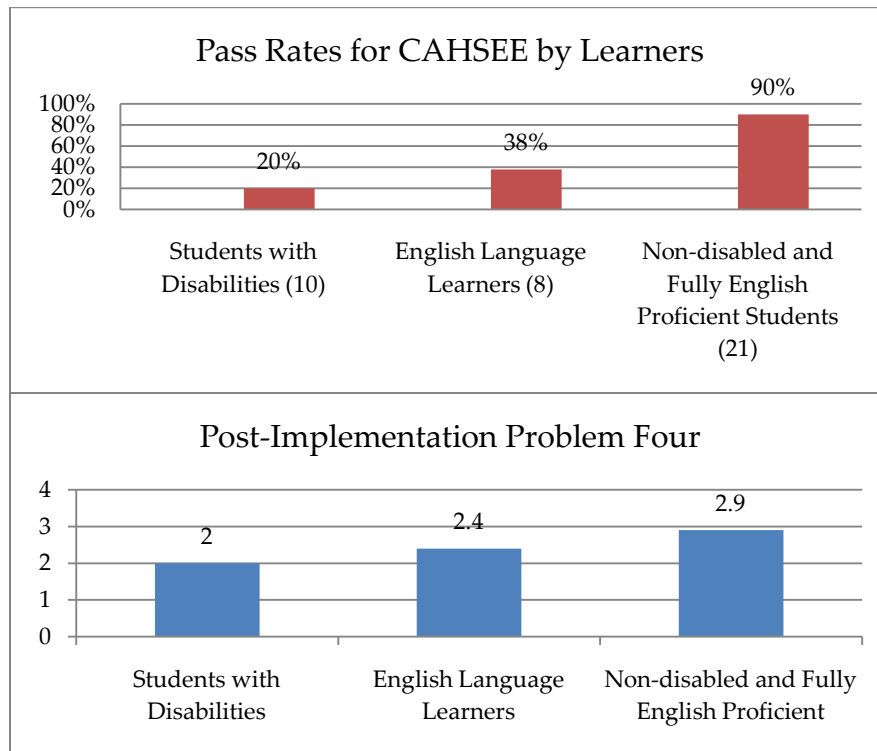


Figure 17: Results of CAHSEE and Post-Implementation Problem Four by Learning Roster

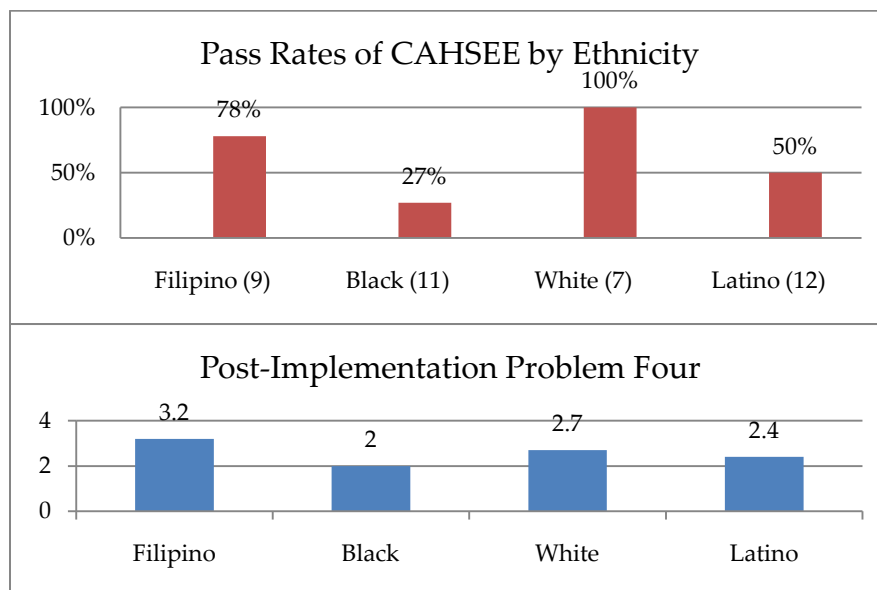


Figure 18: Results of CAHSEE and Post-Implementation Problem Four by Ethnicity

Discussion for the findings for closing achievement gaps in student performance.

The graphs appeared to show that student populations who scored lower than non-disabled, English proficient and White students on the CAHSEE did score relatively better when compared the same peers on Problem Four. However, since graphs do not always reflect true relationships due to scaling issues, mathematical evidence to support this claim was needed. In order to do this, the relative percent of achievement in each category was found by setting the performance for regular education students and White students as the target, meaning that their performance equaled 100% for both assessments. Next, the relative percent of achievement for each student population was calculated.

As an example of this calculation using the CAHSEE, only 20% of students with IEPs passed while 90% of the regular education students passed. To find a relative score between the two populations, divide 20 by 90 which resulted in 22%. Therefore, students with IEPs performed only 22% as well as students without IEPs. Next, the relative score for the same two populations on Problem Four were found. First, students with IEPs scored an average of 2 on Problem Four while regular education students scored 2.7.

Next, dividing 2 by 2.7 produced the result of 74%. Therefore, students with IEPs performed 74% as well as students without IEPs. The change in relative performance from the CAHSEE to Problem Four became more obvious and showed closer performances between the two student populations. Table 15 summarizes the relative performances for both assessments and for all student populations.

Table 15: Comparison of Relative Performances between Student Populations on the CAHSEE and Post-Implementation Problem Four

Student Population	CAHSEE Related Percent (Pre)	Problem Four Related Percent (Post)
Non-disabled and Language Proficient Students	100%	100%
English Language Learners	44%	83%
Students with Disabilities	22%	68%
White	100%	100%
Filipino	78%	119%
Latino	50%	89%
African American	27%	74%

While achievement gaps still appeared, this evaluation shows that the gaps between student populations for Problem Four narrowed when compared to the CAHSEE. Gains are evidenced with ELLs, and with African American and Latino students. Additionally, Filipino students outperformed their White peers by 19%. On the CAHSEE, the lowest relative gap in achievement was at 78% (the difference between students with IEPs and

regular education students). For Problem Four, this relative gap narrowed to a 32% difference for the same population. While these two assessments do not compare the same topics, since the CASHEE measures a broader set of mathematical skills, they do measure performances for the same group of students and they do provide some indication that achievement gaps narrowed after the implementation of *Google Your Math*.

Evidence of Google Activities' Impact on Student Performance

While the results from the post-implementation assessment clearly showed progress and student improvement, this data alone could not identify what impact Google discussion activities had on improved algebraic performance. To explore potential impact, I identified four students who scored the highest on the post-implementation assessment and who also made the most improvement from their pre-implementation assessment. I did this by identifying all students who scored six or more 2's (out of eight possible), on the post-implementation assessment. Subtracting the number of 2's scored on the pre-implementation assessment showed the net improvement per student. This narrowed high performance gains to four students who had a net improvement of six or more 2's. Table 16 shows the breakdown of these

four students by gender, ethnicity, roster, pre and post-implementation tests scores, and the total number of times they participated in Google discussions.

Table 16: Students Who Scored the Highest with the Most Improvement
Based on a Total of Eight Scores on the Pre and Post-Implementation Tests

Name	Gender	Ethnicity	Learner	Number of 2's scored on Pre	Number of 2's scored on Post	Number of posts on Google discussion
Abe	Male	White	IEP	Zero 2's	Eight 2's	9
Katie	Female	Latina	Reg	One 2	Seven 2's	3
Hudun	Female	Native African	ELL	Zero 2's	Six 2's	3
Sherwin	Male	African American	Reg	Zero 2's	Six 2's	10

Findings for Google activities' impact on top four students' performances.

These four students represented the population characteristics of the two classrooms since approximately 25% of my students had disabilities, 20% were non-English proficient, and 55% were non-disabled and English proficient. Additionally, each had participated in the Google discussion activities. I was encouraged by high participation for both Sherwin and Abe, who also represented the mode recorded on Table 12. And with Katie and Hudun participating with less frequency, I was curious if they thought that their participation related to their performance. I interviewed each student

asking them to name one word or phrase to describe their general impressions of Google Groups for math and if they thought that the Google discussions helped them to understand math. Table 17 reports the students' responses.

Table 17: Student Reported Results from Interview

Student	General Impressions	Explanation on if Google was helpful in understanding math
Abe 9 posts	Easy to use	It was helpful because it was a lot easier to use than paper. It was organized on the computer so I did not have to keep track of it. Sometimes I just looked at other posts.
Katie 3 posts	Reliable	It helped more if I did need help because I did go onto the Group even if I did not post. I still looked at what others posted. I didn't always post because I don't always feel confident to post but if I do, then I am pretty confident in my work.
Hudun 3 posts	It was okay	It helped me because people posts answers. You could see how they followed steps. If you answered questions, your grade goes up also.
Sherwin 10 posts	Improvement	It helps because you can see other peoples' answers and compare. The teachers can also explain and that was helpful. Usually, I would go on about four times each week and look to see what other people posted but I wouldn't post.

Discussion for the findings of Google activities' impact on top four students' performances.

All four students stated that Google did help them to understand math and indicated that seeing the posts made by other students were helpful in their understanding. Katie answered my question about less frequency and performance when she reported she went on Google and did not post.

Sherwin confirmed this notion of *lurking*, when a person reads discussions in an interactive system but rarely or never participates, from his statement that he went on several times each week just to see what other students were posting. Additionally, Abe stated that he sometimes just went on to see what others were posting. I also recalled the three times during implementation that Hudun came in during lunch to use a computer and I would see her logon to Google and read the posts, yet when I checked later in the day, she had not made any posts.

Due to the statements and observations from these four students, I wondered how many other students participated without posting. In the post-implementation survey, I asked students whether they went on to Google yet did not post. Thirteen more students reported that they had gone on to Google but never posted. Of these 13 students, five never posted on Google discussion activities. So, while there was confirmed participation through recorded posts from 22 students, five more students reported participating without posting bringing the participation rate from 22 to 29, a total of 69%.

Student non-posting participation is what Lave and Wenger (1991) theorize as a process of learning in which members of the community will participate peripherally at first, then as competency increases, participation

increases in complexity. Perhaps a future study focusing on peripheral participation using Google activities can provide additional connections regarding the impact that Google activities have on student performances.

Findings for Google activities' impact on students with the lowest overall scores on the post-implementation assessment.

In order to get a complete picture of the potential impact Google had on students' performances, it was necessary to look at the participation from the four students who scored the lowest on the post-implementation assessment. Table 18 shows the breakdown of these four students by gender, ethnicity, learner, post-implementation score, and the total number of times they participated in Google discussions.

**Table 18: Students with the Lowest Overall Scores
on Post-implementation Assessment**

Name	Gender	Ethnicity	Learner	Score on post-implementation assessment	Number of posts on Google discussion
Chris	Male	African American	IEP	2	0
Lupe	Female	Latina	ELL	4	0
Eduardo	Male	Latino	IEP	5	0
Jamar	Male	African American	IEP	6	4

Discussion for the findings for Google activities' impact on students with the lowest overall scores on the post-implementation assessment.

Three out of the four students who scored the lowest did not participate in any capacity on Google discussion activities. Both Chris and Lupe stated that lack of a computer at home as the reason for not participating while Eduardo's reason was laziness. Jamar participated in only the first discussion. In the post-implementation survey, he reported forgetting as a reason for not participating.

According to the four students who performed the highest, reading the posts made by other students helped their understanding of the math. Similarly, in the end-of-implementation survey, 12 additional students reported that Google discussion activities helped them to understand math. Therefore, the lack of participation and the low scores received by Chris, Lupe, Eduardo, and Jamar appeared to indicate that non-participation in the Google discussion activities may have resulted in lower performances in math.

Summary and Discussion

I designed *Google Your Math* to provide and establish a collaborative online learning environment where students could access math from outside

of the classroom. Given that students were already using social networking such as MySpace, Facebook, IM, and Twitter, Google's collaborative environment provided both free access and social networking in a restricted, supervised, and focused educational environment. My research questions explored how students used Google activities to support mathematical knowledge building. The prompts and activities that I designed to use on Google evolved from misconceptions and understandings that developed in class and were guided by four knowledge-building principles: knowledge is advanced in a community, knowledge is advanced through idea improvement, discourse is used for collaborative problem-solving, and all understandings are emergent. Creating an avenue for more students to express their *math voices*, which means using language, either verbal or written, to express their mathematical ideas, was my attempt to provide equitable access and to narrow documented achievement gaps.

Local, state, and national performance trends in algebra show achievement gaps across different student populations indicating not all students are accessing the content equally. Students with disabilities and English language learners experience the greatest gap in achievement when compared to non-disabled and English proficient peers. My classroom

consisted of 55% regular education students, 25% special education students and 20% English Language Learners. It was immediately evident that my students possessed varying skills and mathematical aptitudes and would need varying instructional practices that differed from traditional textbook, paper and pencil curricula. Additionally, it was obvious that not all students participated equally in classroom discussions and presentations.

Creating an environment where all students could express their ideas about mathematics allowed more opportunities for students to use their math voices. Adequate amounts of time for English language learners and students with disabilities to process information is rarely available in the traditional setting where content coverage is always an immediate concern. However, this online environment provided students with language barriers and learning disabilities the time to completely process and express their thoughts.

Evaluation of *Google Your Math* allowed me to observe who was participating and the types of knowledge-building interactions that students exhibited on Google discussion activities. The findings indicated increased student participation at home for practicing math. Additional findings showed that *Google Your Math* was accessible for student populations who demonstrated lower mathematical performances, and that students used the

environment to collaboratively discuss math. And finally, the findings showed increases in students' conceptual understanding and procedural performance.

Student participation included regular posting in weekly discussions as well as regular visiting of the site to look at the posts from other students. The evidence of lurker participation was shown in the student interviews and post-implementation survey. Prior to *Google Your Math* only 18% of my students regularly practiced math at home through the traditional methods of worksheets. During implementation, 69% of the students participated in some capacity, even peripherally, on the Google discussion activities. According to research, the apparent increase in my students' participation could indicate greater student interest since I designed the environment to be flexible by offering students choice, providing feedback, and allowing time for reflection and processing (Deci et al., 1999; Deci et al., 1991; Grolnick & Ryan, 1987; Lampert, 1990; Ryan & Deci, 2000).

Additionally, several of my student populations who had demonstrated lower performances in algebra prior to *Google Your Math* accessed the discussion activities regularly. My students with disabilities posted on the Group discussion activities considerably more than regular

education students and English Language Learners. Since this population was small, accounting for only one-fourth of my total population, this participation result may not be significant because of the high variability. However, when individual student postings were coded, it showed that students with IEPs made more postings than any other student population. So, not only were they the student population who had the highest level of participation, but they were also the group who posted the most entries. Therefore, their participation was an instrumental factor in the building of knowledge for their classes. In several of my students' IEPs, it stated that students should use technology to support their learning which may mean that students with IEPs respond well to this mode of learning because using computers has been a form of accommodation in previous learning activities.

Another finding regarding participation was that ELLs accessed the activities slightly more often than fully-English proficient students. With the desired goal to provide instructional practices to support various learning types as well as to promote equity between student populations in mathematical performance, the data indicated that *Google Your Math* did meet this goal, for my diverse student populations.

Another finding was that students interacted collaboratively in Google discussion activities to do math. When the postings were coded, I observed evidence of mathematical discourse and contributions to knowledge sharing. This was important since I was not sure whether or not students would use Google for social interactions or for mathematical discourse and problem solving. Since only 5% of all posts were categorized as being social interactions, 95% posts contributed to the learning of mathematics. However, not all students participated on Google discussion activities. This could be due to the fact that it was a math-friendly environment and therefore not motivating or interesting to all students. However, I do not think that students would have used the Group for social interactions since they reported their social online outlet as MySpace, Facebook, IM, and Twitter.

In regards to students' performances, my data showed that all students improved in both procedural and conceptual knowledge of polynomials. Data also indicated that students who participated regularly on Google activities performed better procedurally and understood math at a higher level than students who did not participate. Additionally, with Google being accessible to students with IEPs and ELLs, the gaps in achievement between student populations were shown to decrease. The observed increase in student

performances can be supported by research which maintains that instructional practices designed to promote student interest have the greatest chance of producing intrinsic motivation which promotes both procedural fluency and conceptual understanding (Deci et al., 1991).

In conclusion, the students who participated in *Google Your Math* showed evidence of increased participation at home and increased mathematical performances in algebra both conceptually and procedurally. Students reported that participation—even peripherally—helped them to understand algebra. Also, *Google Your Math* appeared to be an environment accessible to all student populations. All students who participated reported teacher feedback was helpful. And finally, *Google Your Math* showed evidence of narrowed achievement gaps between my diverse student populations. In chapter eight, I include the findings for a second implementation of *Google Your Math* that took place in my Honors Precalculus.

VIII. Additional Implementation of *Google Your Math*

After finding positive results using Google online activities for my two algebra classes, I was curious about how students from other classes might respond to an online environment for math. This year, I also taught three classes of honors precalculus. With three weeks left in the year, I implemented *Google Your Math* in my sixth period honors class. Due to the Advanced Placement (AP) testing in May, this particular class was scheduled to meet three hours more than my first and fifth period classes. This extra meeting time made it possible to collect email addresses and conduct *The Great Race*.

For my algebra students, I was interested in how students used the environment and how Google activities affected performances in math. The precalculus students differ from algebra students in skill level, work completion, achievement levels, and demographics. This study did not assess how *Google Your Math* impacted mathematical performances due to the timing of this implementation. However, student participation and interaction was observed and recorded and student work samples are provided to illustrate the different ways that students navigated the environment for math.

Additionally, one student commentary describing her impressions of using Google Your Math is also included.

The Students in Honors Precalculus

Google Your Math was implemented in one honors precalculus class with 30 students. This class was comprised of mostly 11th grade students with the exception of four students: two 10th graders, and two 12th graders. There were equal numbers of male and female students, with 15 of each. Student ethnicity was diverse, like those found in my algebra classes. Table 19 shows the student populations for each subject by ethnicity.

Table 19: Ethnicity by Subject

Honors Precalculus		Algebra	
Vietnamese	47%	Latino	31%
Filipino	33%	African American	28%
Latino	10%	Filipino	23%
Chinese	3%	White	18%
Japanese	3%		
White	3%		

The two subject demographics were similar in that the Filipino and Latino students in both Algebra 1 and Honors Precalculus were close to 50% of the total student enrollment. However, the Latino population was three times larger in algebra than in the precalculus class and the Vietnamese

population in precalculus equaled nearly 50% of the total enrollment, yet there were no Vietnamese students in algebra. And lastly, there were no African American students in precalculus but over one-fourth of the population in algebra were African American.

While my algebra students were behind in high school credits which made them at risk for meeting high school graduation requirements, students in my precalculus class were accelerated in math and had acquired more than the required credits for graduation. With honors being the highest level of math that a student can take in their junior year, all my students' performances were similar in effort and achievement. Most students in the precalculus class maintained high grade point averages and were enrolled in the most rigorous classes offered at Needmore High School (NHS) with 77% of my students taking four or more AP and honors classes out of a total of six scheduled classes each day.

Only one student from precalculus was classified as being non-English proficient while an additional ten students had been previously reclassified as English proficient. As in my algebra classes, students in my precalculus classes were instructed in a sociocultural learning environment by working collaboratively in groups to explore concepts, participate in idea generation

and mediation through dialogue, and problem solving. The same pedagogical steps that I took to establish and maintain a safe learning environment in my algebra classes were also taken in my precalculus classes. Therefore students were appropriately prepared to function in an interactive-online environment.

The Activities of *Google Your Math* in Honors Precalculus

Since only three weeks remained in the final semester, this implementation of *Google Your Math* was limited in both scope and activities. I did not assess student content knowledge prior to implementation since we were already in the middle of a unit. Also, with only three weeks until the end of the school year, instructional topics were mostly covered and the major activities that students needed to perform were to take two district finals. Both finals were cumulative, covering both first and second semester topics. One final focused on problem solving with four open-ended questions, and the second final focused on overall course content with 50 multiple-choice questions.

Therefore the content focus of *Google Your Math* was to practice topics in the current unit and to practice problem solving to prepare for the final. The total implementation activities consisted of *The Great Race*, three Google discussions designed using the same four knowledge-building principles as

were used in the original implementation, and a post-implementation student survey.

Implementing *The Great Race*.

In the original implementation, the most time-consuming part was inviting students to the Group and getting all students logged in. To adjust for the difficulties I experienced with my algebra students, the students from my precalculus class entered their email addresses directly onto the pre-created Group for their class, while I was logged in as Administrator. This reduced my pre-implementation time by at least one hour from the time it took for me to invite my algebra students to their Groups. Another step to reduce time was to show students the Group the same day that they entered their email addresses, and I then asked them to try to login to Google at home that night. I also posted a problem called Just for Fun for students who were successful in logging in to the Group and who might want to start participating.

The Great Race was implemented the following day using the same format and clues as used in my algebra classes with one difference. In clue three for my algebra classes, students were required to discuss the page that their team had created by writing something positive about each team

member. For this implementation, I decided to incorporate the use of Google's search engine to encourage students to 'Google' their math and I wanted them to be confident in posting their own problems to the Group. So, on the third clue, students used Google to find an interesting math problem and posted it as a discussion item on their page.

Due to AP testing, our class meeting on the day of *The Great Race* was two hours in length. This allowed ample time for students to complete the race and to begin their first online activity on Google. At the end of the class period, all students had successfully logged in and had completed all the clues eliminating the variable of logging in as a reason for non-participation.

Google Discussion Activities.

Three discussion activities were designed for this study. For the first discussion, I simply required students to solve one problem that another team had posted on their team page and to monitor one posting made on their team's problem. For the second discussion, I provided four problems and required students to solve one of the four. Additionally, they were required to reply to someone else's post during the week. In the third discussion, I did not create a prompt for the discussion page on Google since so many students were responding to the same problems. Instead, I created eight problems, one

for each team to solve, and placed each on a Google Document that was shared between each group member and me. And finally, I used the Google Group to communicate with my students by posting the names of partners for upcoming tests and the solutions to a group test.

The Findings of *Google Your Math* in Honors Precalculus

Within ten minutes of inviting students to the Google Group, Jake logged in to Google using a student computer and submitted a response to the Just for Fun problem. In total, four students submitted responses and replied to Jake's initial post on this problem. Over the entire three weeks, twenty-eight out of 30 students participated in some capacity and 16 students posted more than their weekly assignment quota, meaning that 93% of the students had used Google at least once and that 53% were using Google more than was minimally required.

Additionally, fourteen individual problems were posted by students to challenge other students even though that was not a requirement I had set. I noticed that the Google Group for Honors Precalculus, from the onset, had taken on its own identity: that of an honors math community. Of these fourteen problems, 12 were answered by other students, with one student answering six of the problems and another answering five. In total, thirteen

students (43%) participated in posting and answering problems I did not assign. However, not all discussion activities received the same student participation. Student participation on Google discussion activities was evidenced when students posted online by sharing knowledge, explaining methods, clarifying information, giving and receiving feedback, challenging each others' contributions leading to negotiation and resolution, and monitoring peer efforts and contributions. Only eight students (26%) participated in the requirements of the first discussion, fifteen (50%) participated in the second discussion, and 28 students (93%) participated in the third discussion.

Interestingly, the precalculus students interacted personally and directly with their peers by regularly referencing individual students in their posts. This differed from the interactions I observed between algebra students who rarely referenced their peers in their postings. Also, precalculus students challenged and reacted to challenges with spirited discussion, and their posts were academically complex in both their ability to provide a solution and an explanation. Using the same coding schema as in the original implementation, (shown in Table 11) I coded the online interactions between students which are shown in Table 20.

Table 20: Coded Student Online Interactions

Behavior categories	Code	Total	Code percent	Category percent
Planning	OW	2	1%	1%
	IA			
Contributing	HeG	1	1%	76%
	FBG	23	12%	
	RI	0	0	
	SK	92	50%	
	Ch	14	8%	
	Ex	10	5%	
Seeking Input	HeS	9	5%	10%
	FBS	8	4%	
	Ef	2	1%	
Reflection/ Monitoring	ME	18	10%	13%
	PC	6	3%	
Social Interaction	SI	0	0%	0%
Post Totals		185		
Participating Students		28		
Average Post		6.6		
Median Post		4		
Mode		18		

Discussion of the Findings for *Google Your Math* in Honors Precalculus

Overall, a higher percentage of students from honors precalculus posted than from algebra. When comparing the total posts of 185 in three weeks (an average of 62 posts per week) from my precalculus class to 79 posts for four weeks (an average of 20 posts per week) in my algebra class, precalculus students participated in the environment three times more than

the algebra students. Additionally, student-initiated use of Google in precalculus comprised of 54 posts, which meant that nearly 30% of all posts were not required by the instructor. According to Deci (1995), students with greater levels of understanding have greater levels of intrinsic motivation, which in this case, led to greater participation for my precalculus students.

However, the types of online interactions between the two student populations were almost identical. Both precalculus and algebra students contributed knowledge more than any other type of interaction with 76% of these posts made in precalculus and 71% of these posts made in algebra. Additionally, algebra students sought input slightly more at 15% than precalculus students at 10% while precalculus students monitored other students' posts slightly more at 13% than algebra students at 9%. And finally, 5% of the student posts from algebra were coded social interaction while all the posts made by precalculus students were based on topics only related to math.

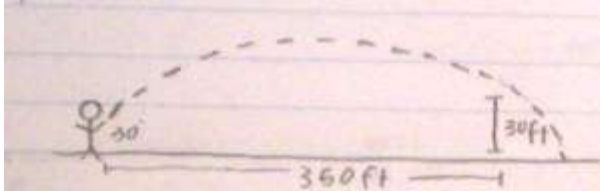
The average number of posts per precalculus student was 6.6, the median was 4, and the mode was 18. However, unlike in the algebra classes, there was no outlier since several students posted near to the mode of 18 posts. The honors precalculus class did not have different learning rosters;

therefore, analysis by different rosters was not used for comparison as was done for algebra.

To address the issue of lurker participation, 21 precalculus students (70%) reported that they logged into Google and did not post although none of these 21 students were the two who had never participated. The reasons that students stated for not posting were various, including: not having anything additional to add, that all the problems were already solved, and that they were looking for new problems to solve or new information posted by me regarding the class. Similar to my algebra students, these findings indicated that students were participating by watching and not posting, which is supported by Lave and Wenger's (1991) theories on peripheral participation.

I also found evidence of more complex participation from precalculus students when compared to algebra students in the quality of their posts and in their creative methods for representing their work. While some students found the limited capacity for representing mathematical expressions on Google to be cumbersome, the majority of precalculus students incorporated outside programs for graphing and devised other methods to overcome the limitations in Google. These acts of ingenuity were not performed by my

algebra students. Figures 19, 20, and 21 provide examples of different ways students represented their work on Google for the second discussion.



a) Horizontal distance: $x = v_0 t \cos \theta$ (v_0 = initial velocity)
 $x = 120 t \cos 30$
 vertical distance: $y = -16 t^2 + v_0 t \sin \theta + y_0$ (y_0 = initial height)
 $y = -16 t^2 + 120 t \sin 30 + 4$
 $120 t \cos 30 = 350$
 $t \cos 30 = \frac{350}{120}$
 $t = \frac{350}{120 \cos 30}$
 $t = 3.37 \text{ sec}$
 $y = -16(3.37)^2 + 120(3.37) \sin 30 + 4$
 $y = -181.7104 + 202.2 + 4$
 $y = 24.5 \text{ ft}$
 Does the ball clear the fence? No, because the ball's height is only 24.5 ft and the fence is 30 ft high

b.) $x = 120 t \cos 30$
 $x = 120(3.37) \cos 30$
 $x = 350.22 \text{ ft}$
 The ball travels 350.22 ft before hitting the ground for the first time

Figure 19: Charlene's Solution Created on tinypic Hyperlinked to Google

Given: $4x^2+25y^2+16x-150y+141=0$
 Graph and identify everything you know about this conic section.
 (You will need to figure out how to show this on Google!)
 this on Google!)

Okay let me break this down Chandler's Way. This is where Doomsday begins.

- 1) Given: $4x^2+25y^2+16x-150y+141=0$ WOW!
- 2) Put the Xs with the Xs and the Ys with the Ys. SPECTACULAR!
 Make the 141 equal the equation:
 $4x^2+16x+25y^2-150y=0$
- 3) Take out 4 as the common factor in the Xs and OUTRAGEOUS!
 16 as the common factor in the Ys and complete the square:
 $4(x^2+4x+4)+25(y^2-6y+9)=-141+(4 \times 4)+(25 \times 9)$
- 4) Compact the squares and add the multiplied numbers (4×4) NOT PLATITUDINOUS!
 and (25×9) to -141:
 $4(x+2)^2+(25(y-3))^2=100$
- 5) Divide everything by 100 NOT PLATITUDINOUS!
 $((x+2)^2/25)+((y-3)^2/4)=1$

Well look at the marvelous masterpiece, it's an Ellipse!

As you can see the bigger denominator always being a^2 is under the X^2 making it in the X Axis for the Focal Axis.

Well using the equation for any Ellipse, $((x-h)^2/a^2)+((y-k)^2/b^2)+1$, we can reflect back at this problems equation as find out:

A) $a^2=25$, so $\sqrt{25}=5=a$ SHAZAM!
 $b^2=4$, so $\sqrt{4}=2=b$
 $c^2=\sqrt{(a^2-b^2)}=\sqrt{(25-4)}=\sqrt{21}=c$

B) Major Axis Length: $2a=2(5)=10$ DAREDEVIL!

Vertices: $(3,3)$ $(-7,3)$

C) Center: $(-2,3)$ OUT OF MY MIND!

D) Minor Axis Length: $2b=2(2)=4$ LEGIT!

CoVertices: $(-2,5)$ $(-2,1)$

E) Foci: $(-2+\sqrt{21},3)$ $(-2-\sqrt{21},3)$ CAN WE SAY BONUS POINTS?!

F) Eccentricity: $e=a/c=\sqrt{21}/5$ INDUBITABLY!

G) The graph of the century is one click away. i warn you that it's unique. GASP!

I know, this is some crazy work here. No need to give me a gold medal

Figure 20: Chandler's Solution using Keyboard Symbols

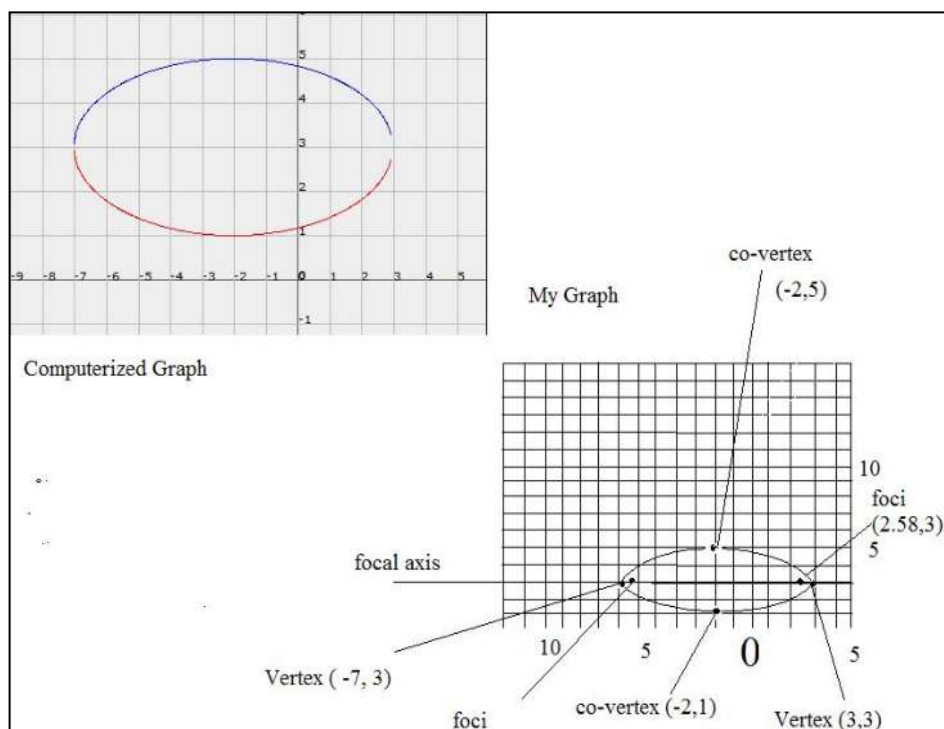


Figure 21: Chandler's Graph Work for Figure 20 Imported from a Program

In Figure 19, Charlene wrote out her steps, graphed the problem, and provided a solution using paper and pencil. She then took a photograph of her work, and posted it using tinypics' web-based site. In Figure 20, Chandler showed his work in Google discussions using regular keyboard symbols. He then supported his work with the graphs shown in Figure 21 which were produced using a graphing program. These three samples, provided by two students illustrate just a few of the methods that students devised to show their work to solve problems. Additionally, these samples are typical of the posts made by most precalculus students which contained more detail and

longer explanations than those made by the students in algebra. Some students used sarcasm and humor in their posts, and in all cases, their writing was considerably more academic. Both Charlene and Chandler provided explicit detail in their solutions and Chandler's post provided an entertaining dialogue throughout his solution.

Students in precalculus expressed an overall interest in using Google discussions and the majority indicated on the post-implementation survey that they would like to use *Google Your Math* for the entire year. They also indicated their favorite activities. Eight students stated that they favored the Google Document group problem solving and seven students favored *The Great Race*. The remaining students, 13 stated that they enjoyed particular aspects of Google activities such as: being able to solve challenging and atypical problems (7 students), the ability to post their own problems (3 students), solving riddles (2 students), and using Google to search for problems (1 student). The following quote from Emma describes her feelings regarding her participation in the Google Document group activity used for the third discussion:

My favorite activity on Google was being challenged to solve problems that weren't the ones that we normally see. For example, my group had to solve a problem about the illumination of the moon. Even though there were parts that

stressed me out because I was having difficulty solving it, the coming together of people to do the group work was fascinating. Since this group was made up of people that I would never usually talk to it was an unforgettable experience. The thing that makes it so memorable is the fact that I saw that my group was editing the document for over an hour on the night it was going to be due. This demonstrated to me that there were people in my class who were dedicated to finish solving the problem, which essentially made me feel more connected to other people in my class.

Finally, 81% of the precalculus students who participated reported that Google helped them to better understand math, while 26 out of 28 students stated that getting peer and teacher feedback was helpful to their understanding of the math concepts. Additionally, 79% of the students reported that they felt connected to their peers and teachers using Google. These student reports agreed with the findings from my algebra classes and with theories regarding intrinsic motivation in which students found both feedback and participation helpful in understanding math.

IX. Project Conclusion

Google Your Math was developed to extend the social aspects of learning math through discourse, reflection, and discovery. Lampert (1990) argues that mathematical discourse is an important way for students to communicate and express their understanding about mathematics in order to firmly situate the learning that occurs in the classroom. She further states that activities that require reflective thinking about mathematical concepts are likely the most valuable types of discourse activities; however, teachers are rarely able to give students enough time in the classroom to complete such tasks. Google's socially interactive environment presented a way to incorporate reflective thinking and discourse beyond the classroom.

The outcomes from this study for both implementations support Deci's theory (1995) regarding relationships among motivation, conceptual understanding, and procedural fluency. Appealing to the different learning styles and learning needs for both algebra and honors precalculus students, *Google Your Math* provided an opportunity to differentiate math instruction as well as to provide continued support outside of class. The students who participated on Google were encouraged by teacher and peer feedback and continued their participation in order to increase conceptual understanding.

In algebra, the students who used Google Groups to practice their math were also the students who experienced the greatest gains in conceptual understanding.

Recently, every high school math classroom at Southern Unified School District (SUSD) was equipped with student notebook computers allowing online access. The findings from *Google Your Math* may have strong implications in the future of mathematical teaching at districts like SUSD, who are just one of several districts increasing their use of notebooks or other means of online access. As a department chair and a teacher instructional leader, I am excited about the potential *Google Your Math* has for my future instruction and lesson design in math as well as in the opportunities that using Google has for a community of math teachers.

To launch *Google Your Math* at my local site, I plan to present the findings of this study to my colleagues and invite them to participate in teacher dialogue on a Google Group. Here, teachers choosing to participate, will discuss their ideas and collaborate on ways to better their teaching practices. Contributing to discussion pages, teachers will be able to create prompts and activities designed to use on their classroom Google Group and to share them with their peers on the teacher Google Group.

From my past experiences in collaborative curriculum creation, relating stories and best practices is an exciting and motivating activity for teachers. Similar to how my students felt when they received peer and teacher feedback, I too am motivated by collaborative curriculum design. I look forward to receiving teacher feedback describing the outcomes of an activity they had implemented using Google. Discussing both successful and unsuccessful activities will increase teacher awareness for future designs. Informed collaborative instruction design would be a valuable and usable outcome for this new-aged technological adventure.

So, why stop at the site level? Once the teacher Group is functional at my site, why not invite other district teachers to join? During this current era of budget constraints, time for district-wide collaboration and planning is limited at best. Even time for professional development at the site level has been radically reduced due to decreasing funds. Google could create a cyber environment for constant, emergent, and creative communication between teachers who teach common math subjects throughout the district. But why stop at math? Who says that this type of curriculum is math specific? The majority of my students thought using Google would be helpful in their other

subjects, so why not Google Your English, Google Your Science, or Google Your Art?

For teachers who want to participate yet have barriers in doing so, such as lack of technology expertise, participating teachers could volunteer to be site leaders who report ideas to and from their sites using email or face-to-face professional development. Additionally, to support a larger community of teachers, my school could host afterschool workshops in a computer lab for teachers who wish to set up Google accounts, brainstorm ideas, and get support for implementing Google activities in their classroom.

Final Words

My next implementation will begin at the start of the school year rather than at the end. For some students, change is difficult. Bringing *Google Your Math* in at the end of the year, when habits are already established, may have been a factor in the lack of participation for my algebra students.

I would also like to provide scaffolds for the use of academic English next year in algebra. However, I need to be careful to not over emphasize spelling and grammar with emerging writers, since according to Cummins (2000) this practice will likely reduce or even destroy students' intrinsic motivation to participate.

And finally, I would like to further explore Lave and Wenger's (1991) theoretical framework on situated learning in future implementations of *Google Your Math* within the communities of students and the communities of teachers. For both communities, I would like to focus on the peripheral participation of novice students in math and novice teachers in technology by incorporating scaffolds designed to increase their confidence, understanding, and competency during their participation.

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*Activities created in collaboration with Dwight Fuller and Mike Mitchell.
All other activities are created by the author.

Teacher Letter

Dear Fellow Educator,

I designed *Google Your Math* as a way to blend classroom instruction with an online learning environment to maintain and support student learning outside the classroom. I activated one Google Group for each of my two algebra classes in order for my students to continue building mathematical knowledge. Since my primary goal in developing this curriculum was to get more students to do math activities at home, it is necessary for students to have some type of computer access outside of the classroom. The in-class curriculum is easy to facilitate in classrooms with access to student computers but can be also implemented in classrooms with limited computer access. While I implemented this curriculum with only one student computer for every group of four students, you may wish to take your students to a computer lab before using Google Groups to teach them how to navigate the group and how to use Google Documents and Google Spreadsheets.

I launched this project with an activity I designed called The Great Race. I strongly suggest using this activity as it guides student teams through the process of creating an account, logging on to Google, finding the Group,

navigating the Group, posting to the Group, editing student profiles, and creating and sharing Google Documents. Students enjoyed this activity and participated with a spirit of competition. Detailed instructions on how to create and maintain a Google Group are described in The Great Race Teacher Instructions included in the Appendix.

When students were able to logon to the Group, I posted one discussion activity each week for the duration of the project to motivate student dialogue centered on mathematical topics that were learned in class. I decided to continue using the Group discussions after implementation of this Project to continue student support. In addition to the weekly discussion prompts, students collaboratively completed the unit project on Google Spreadsheets.

Google Your Math was used for an Algebra 1 unit on polynomials but the prompts and unit project can be easily revised to support any unit of middle school or high school math (which I evidenced when I implemented *Google Your Math* in my honors precalculus class). I have included all of the in-class activities that I created in which students used algebra tiles to create polynomial area models. The pre and post-implementation assessments were created to monitor growth on conceptual fluency and procedural fluency.

These assessment activities can easily be written to assess any content standard or topic in math. I also believe Google can be incorporated into any classroom curriculum and my students indicated that they would particularly find Google discussions useful in English and science classes. I hope you will find it valuable in providing alternate methods for meeting the diverse needs of your learners.

Sincerely,

Kimberly Samaniego

The Great Race

For Teachers: This Activity launches the unit and introduces students to the Google Group. Additionally, it is designed for students to collaboratively explore and navigate through Google to accomplish small activities and tasks.

Prior to Implementation:

1. Creating an account:
 - a. If you do not have an account with Google, you will need to create one (even if you have Gmail):
 - b. Go to Google.com. At the top right, click "Sign in."
 - c. Go to the bottom right and click "Create an account now."
 - d. Using your current email, fill in all the fields. (If you have a Gmail account, it is easier to connect everything. I would recommend creating a Gmail account first if you do not have one.)
2. Creating a Group:
 - a. You will need to Sign in to Google. Then using the "more" menu tab at the top, click on Groups. This takes you to Google Groups.
 - b. Click on "Create a group..."
 - c. Fill in all the required fields. I made sure to make my groups restricted so that only members that I invite may view, post, and participate on the Group.
3. Inviting members:
 - a. Go to the "Members" tab at the right side and click on "+ invite new members."
 - b. Click on "Add members directly" and manually enter the email addresses of each student. (You may want to collect these weeks before starting the activity or you may want to have students come up and enter their email in one-by-one at your computer).
4. Formatting the group:
 - a. You can format and design the Group any way you want. I created the following pages: Discussion, Pages, Files, and Members
 - b. Go to "Group Settings" at the right menu tab and check the Access and Appearance. Tune these to your needs.

5. Getting ready for The Great Race:

- a. If possible, make sure that every student can log into the group before beginning, but since this is difficult to do and very time consuming, it is also part of this activity.
- b. Create a page named Great Race Problem with the problems that you want students to solve for Clue #4. Download it as a file onto the Group.
- c. Form teams of 3 or 4 students (these teams will stay together for the entire unit). I formed teams using two criteria: The first, I made sure that every student was supported in language and skills in every group (meaning that every struggling student had a peer that could help, and every EL student had a peer that could help). Second, I gave students a choice in who they wanted to work with. I asked them fill out a card indicating two students who they liked or worked well with. In all cases, I was able to give students one of the two students that they listed and still meet the learning needs of my students.
- d. Cut out the clues provided on the next page and organize them so that you can hand them out quickly to students. Have the first clue already in an envelope with before starting. Have students keep all their clues in the envelope in case you need to return to the Race on a different day.

Implementation:

1. Introduce the activity by telling students that they are going to participate in the Great Race.
2. Have students move into their pre-determined teams.
3. Explain the rules:
 - a. how students will access a computer (I had one per group)
 - b. how students post using appropriate language
 - c. how students use academic language (I did not allow use of any acronyms unless it was math related like GCF)
 - d. the procedure for how students proceed through each clue
 - e. how students are awarded points
4. Once every student understands the procedures and how the activity works, hand out the first clue in an envelope to each group.
5. Be ready at a computer to trouble shoot and to check team results as they come in. Continue to encourage teams to proceed through their sets of clues in order to finish the race.

6. Prepare to give ample class time (more than 50-60 minutes) and have an activity ready for those who finish early.

Clue # 1:

1. Name your team – something related to math (make sure it is school appropriate).
2. Give each team member a code name from the following: diamond, ruby, emerald, topaz (this is the order that you will complete the next tasks).
3. Write this information on your envelope.
4. Return to your teacher for this clue's check out and for the next clue.

Clue #2

1. Diamond: Go to (or get in line for) an unoccupied student computer.
2. Go to Google.com and Login.
3. Find the Google Group for your period.
4. Go to Pages and add a new page. Title the page the name of your team. On the page, list the names of everyone in your team and their code name – when finished, save and publish (hit "skip this" at the end).
5. Find yourself in Members and edit your profile. Write something brief about yourself (school appropriate).
6. Log out of Google and Student.
7. Return to your teacher for this clue's check out and for the next clue.

Clue #3 (Option 1)

1. Ruby: Go to (or get in line for) an unoccupied student computer.
2. Go to Google.com and Login. Return to the Group.
3. Open the page that your team created and click on "Edit this page". Write something positive about your team in this box (again, school appropriate) and post.
4. Find yourself in Members and edit your profile. Write something brief about yourself (school appropriate).
5. Log out of Google and Student.
6. Return to your teacher for this clue's check out and for the next clue.

Clue #3 (Option 2)

1. Ruby: Go to (or get in line for) an unoccupied student computer.
2. Go to Google.com and Login. Return to the Group.
3. Open the page that your team created and click on "Edit this page". Search for an interesting problem on Google for others to solve and post. Hit "skip this" at the end (if it shows up).
4. Find yourself in Members and edit your profile. Write something brief about yourself (school appropriate).
5. Log out of Google and Student.
6. Return to your teacher for this clue's check out and for the next clue.

Clue #4

1. Emerald: Go to (or get in line for) an unoccupied student computer.
2. Go to Google.com and Login. Return to the Group.
3. Open the File called Google Great Race Problem. Have every team member copy down the problem in their tool kit. Close the file.
4. Return to the Google Group and find yourself in Members. Go to edit your profile. Write something brief about yourself (school appropriate).
5. Log out of Google and Student.
6. Return to your teacher for this clue's check out and for the next clue.

Clue #5

1. At your desks, solve the problem in your tool kit from the last clue.
2. Topaz: Go to (or get in line for) an unoccupied student computer.
3. Go to Google.com and Login.
4. Go to Google Docs (see header at top).
5. Create a new document and title it as your team's name.
6. Write your team's solution on this document. Include an explanation of your steps. Use superscript in the insert menu to write exponents.
7. Save the document.
8. Share it with everyone in your group and with your teacher. You do this by clicking on share, then "invite people". Add all of your email addresses and add the teacher's email address. At the bottom of the "Share with others" window, click "Add without sending invitation." When the skipping invitations window appears, click "OK."
9. Go to Google Groups and enter our Group.
10. Find yourself in Members. Go to edit your profile. Write something brief about yourself (school appropriate).
11. Return to your teacher to claim your reward.

Possible Scoring Rubric (worth 8 points per student)

Value of Activity: Total 32 points (divided between four team members)

First place – 32 points plus 12 points EC

Second Place – 32 points plus 8 points EC

Third Place – 32 points plus 4 points EC

Fourth Place – 32 points

Fifth Place – 28 points

Sixth Place – 24 points

Algebra 1

Name: _____

*Google Your Math***Pre Assessment – Box it Up!**

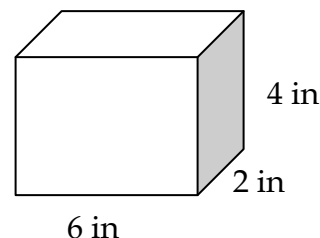
Please answer the following questions to the best of your ability. This Pre-Assessment will help your teachers determine your current understanding as well as to design activities to meet the needs of this class. Your work will be scored using the rubrics listed below on the back. Do not leave problems blank.

Use the following rubric for how you will be assessed.

Conceptual Understanding	0 points – no explanation 1 point – explained an incorrect process 2 points – explained a correct process
Procedural Fluency	0 points – did not try or used an incorrect procedure 1 point – used a correct procedure but made errors 2 points – used a correct procedure with accuracy

1. Given the rectangular prism at right, calculate the following.

- a. Calculate the volume (procedural fluency).



- b. Explain your solution completely (conceptual understanding).

2. Use the same rectangular prism to answer the following.

- a. Calculate the surface area (procedural fluency).

- b. Explain your solution completely (see for conceptual understanding).

3. Given $3x(4x^2 - 5x - 7)$.

a. Find the product (procedural fluency).

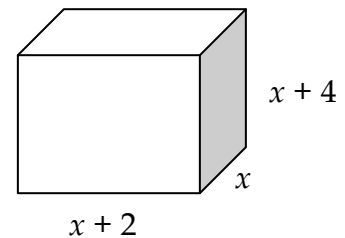
b. Explain your solution completely (conceptual understanding).

4. Given $(3x + 2)(4x^2 - 5x - 7)$.

a. Find the product (procedural fluency).

b. Explain your solution completely (conceptual understanding).

Challenge Problem: Given the rectangular prism.



a. Calculate the volume (procedural fluency).

b. Explain your solution completely (conceptual understanding).

Discussion Week 1 – *Google Your Math*
Polynomial Unit

In one of the problems on the Great Race, students were asked to simplify $(3x + 2)^2$.

Explain why the answer is NOT $9x^2 + 4$.

The following are ways to participate in this discussion:

1. You can answer the prompt by explaining why the answer is not $9x^2 + 4$ and then by providing the correct solution.
2. If you do not know why the answer is not $9x^2 + 4$, then you should post a question so another student can give you assistance.
3. If you agree with another student's explanation, then you need to provide justification why you agree.
4. If you disagree with another student's explanation, then you may offer clarification to this student or express reasons why you question their explanation.
5. You may reply to any student's post when participating in this discussion yet your participation should have purpose.

The more you participate, the more opportunities you have to earn points.

Discussion Week 2 – *Google Your Math*
Polynomial Unit

Suppose you have a box with the following dimensions:

- a. The width is x inches long.
- b. The length is two inches more than the width.
- c. The height is three inches more than the width.

Draw a sketch to help you and then answer the following questions to participate in this discussion.

1. What is the volume of this box in cubic inches? Explain.
2. What is the surface area of this box in square inches? Explain.

Challenge Problem: How does the volume change if you double all the dimensions?

Google Your Math* - Question worth 5 points and potential Extra Credit*Posted on Discussions Week 2**

I will award 10 points extra credit to the first THREE students who correctly answer the question below. I will give 5 points to every student who answers correctly.

DO NOT reply to this post. In order to receive credit, you need to send me an email with your answer, so it will be confidential. The answer must be readable with good spelling and good grammar. And, you **MUST** cite the source where you found the answer. (No credit will be given without proper citation.)

Remember, emails are posted by time, so I will know who the first three are.

Due: _____

QUESTION: What is a “Google”?

Discussion Week 3 – *Google Your Math*
Polynomial Unit

We have been practicing factoring in class this week. In order to determine if a problem factors and how to factor the problem, you should ask yourself several questions such as:

- Is there a GCF?
- Do we need to use the X- Factor?
- Is this an easy X-Factor or one where we need to rewrite?

Please factor the following considering all the questions above.

$$45x^3 + 48x^2 - 21x$$

For more credit, create your own polynomial to factor for other students. For even more credit, factor another student's problem.

Discussion Week 4 – *Google Your Math* Polynomial Unit

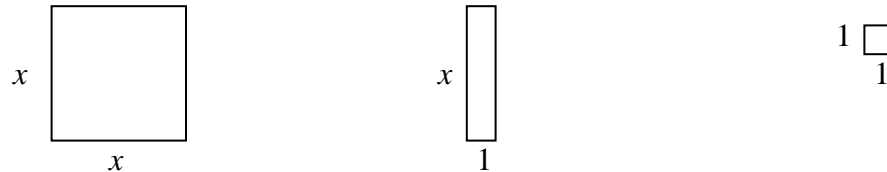
This week, there will not be a new prompt. In order to participate in this week's discussion you may do any of the following:

1. Continue working on the prompt from Discussion Week 3 (no one has the correct solution). If you choose this option, here are some things to consider:
 - a. $3x$ is the GCF and $3x(15x^2+16x-7)$ is equal to $45x^3 + 48x^2 - 21x$. So why is the answer NOT $3x(x - 5)(x + 21)$?
 - b. What are numbers that can multiply to give you $15x^2$?
 - c. Try different factors or use the X-factor.
2. Create your own discussion based on any questions that you may have on the Project.
3. Create your own discussion based on any questions that you may have on the assignments this week.

Participate in any mathematical discussion that has been started so far.

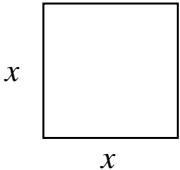
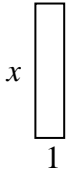

The Patio Builders

Imagine that you are on the internet when you run across an advertisement for a very unusual company called *The Patio Builders*. It seems that they sell customized patio tiles in whatever size you want. Well, not exactly. What they do is ask you for one number, say it is “ x ”, then they make tiles that are x feet by x feet, x feet by 1 foot, and 1 foot by 1 foot, like this:



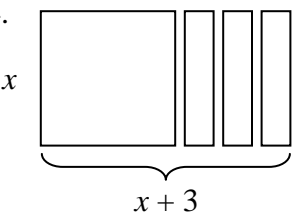
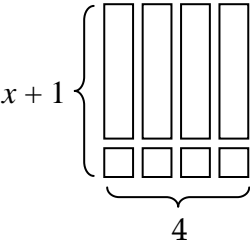
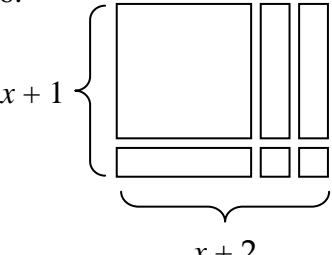
Since every tile is either x feet long or 1 foot long, they always fit together perfectly. By connecting x 's with x 's and 1's with 1's, you can put them together to make any size patio you want. It's looks like a neat system! Let's investigate more to see how it works.

Here are some of the diagrams on *The Patio Builders*' website to show you how easy it is to put their tiles together. The dimensions are shown on the side of each diagram. Calculate the area of each:

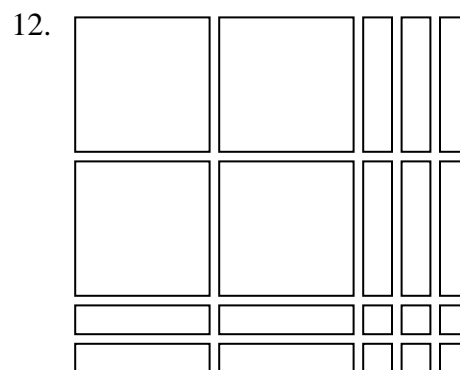
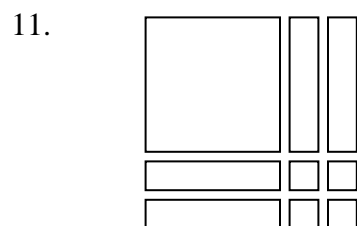
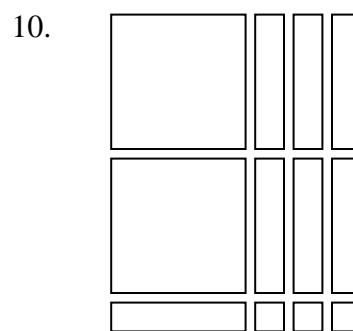
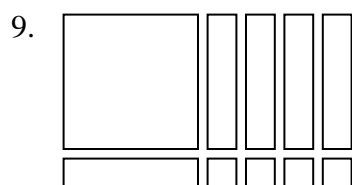
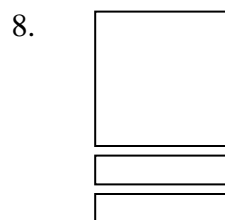
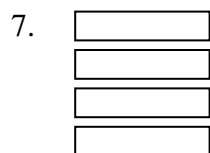
1. 	2. 	3. 
---	---	---

These are the three basic tiles that *The Patio Builders* company makes. Let's agree to call the first one an “ x^2 ” tile, the second one an “ x ” tile, and the third one a “1” tile, after their areas.

In the following problems, count how many of each of the above tiles are in the patio as a shortcut to finding the area.

4. 	5. 	6. 
--	--	--

Write the dimensions on each of these patios. Then calculate the area.



Patio Plans

If you are interested in their unique system, The Patio Builders send you miniature tile samples so that you can build a model of a patio to see how many of each type of tile you will need in the finished product. Your set of tile samples can be found at the back of this unit.

Use the tile samples to build a model of a patio with the indicated dimensions. Draw a small sketch of each, then calculate the total area of the patio by adding up the areas of the individual pieces.

1. x feet long and 3 feet wide.

2. x feet long and $x + 1$ feet wide.

3. $x + 1$ feet long and $x + 1$ feet wide.

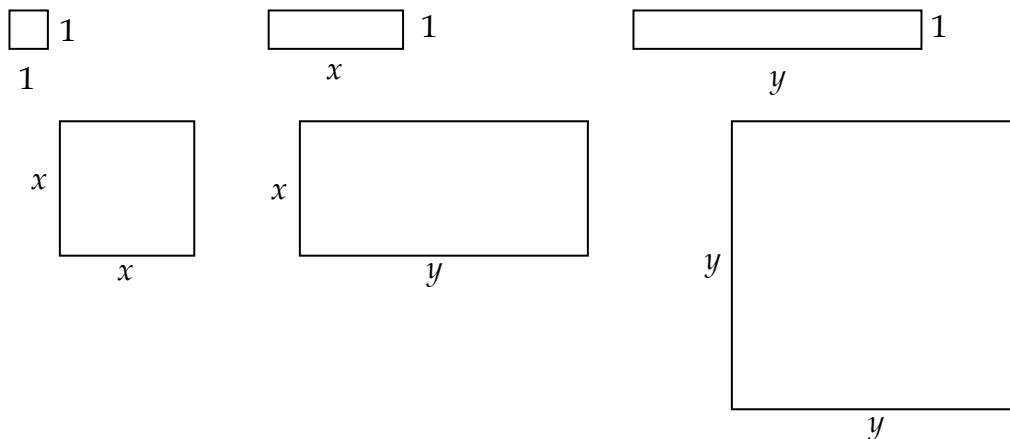
4. $2x$ feet long and $x + 1$ feet wide.

5. $2x + 1$ feet long and $x + 2$ feet wide.

6. $x + 4$ feet long and $3x + 2$ feet wide.

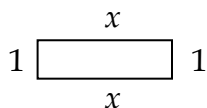
Just Simplify It!

Suppose *The Patio Builders* allow you to make each of the six basic tile shapes below.



Below, tiles like these have been arranged to form rectangular shapes. For each shape, place the dimensions on each side. Then find the perimeter and area of the shape.

Example:



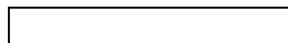
$$P = x + 1 + x + 1 = 2x + 2$$

$$A = x \cdot 1 = x$$

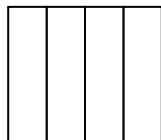
1.



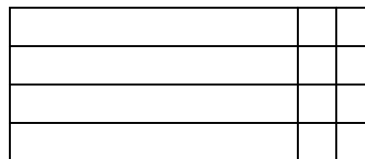
2.



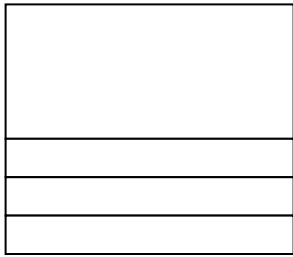
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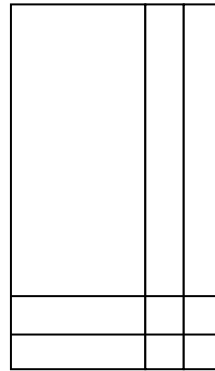
4.



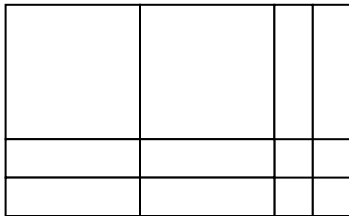
5.



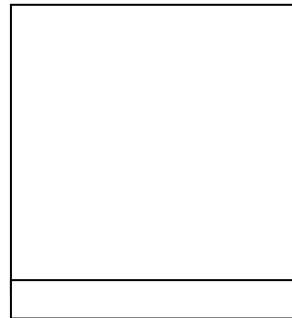
6.



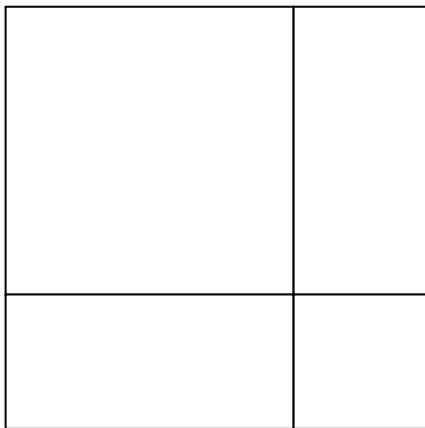
7.



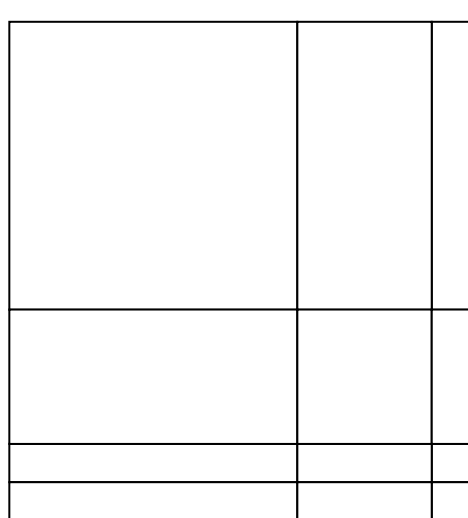
8.



9.



10.



Polynomial Patios

For each question below, complete the following steps:

Step 1: Arrange a set of tiles to form the indicated rectangle.

Step 2: Draw a sketch of your tile arrangement.

Step 3: Write the dimensions on your sketch.

Step 4: Determine the perimeter or area as indicated.

Example 1: Given that the perimeter is $4x + 2$, what is the area?

$$\begin{array}{c}
 x \left\{ \begin{array}{|c|} \hline x^2 \\ \hline \end{array} \right\} x \\
 \hline
 A = x(x+1) = x^2 + x \underbrace{\hspace{1.5cm}}_{x+1}
 \end{array}
 \quad P = x + x + 1 + x + x + 1 = 4x + 2$$

Example 2: Given that the area is $2x + 4$, what is the perimeter?

$$\begin{array}{c}
 \begin{array}{|c|} \hline x \\ \hline \end{array}
 \begin{array}{|c|} \hline x \\ \hline \end{array}
 \begin{array}{|c|} \hline 1 \\ \hline \end{array}
 \begin{array}{|c|} \hline 1 \\ \hline \end{array}
 \begin{array}{|c|} \hline 1 \\ \hline \end{array}
 \begin{array}{|c|} \hline 1 \\ \hline \end{array}
 \end{array}
 \longrightarrow
 2 \left\{ \begin{array}{|c|c|c|c|} \hline x & 1 & 1 & 1 \\ \hline x & 1 & 1 & 1 \\ \hline \end{array} \right\}
 \longrightarrow
 P = 2 + x + 2 + 2 + x + 2 = 2x + 8$$

$x + 2$

1. Perimeter is $2x + 4$. Find the area.

2. Area is $4x + 2$. Find the perimeter.

3. Area is $3x + 9$. Find the perimeter?

4. Area is $x^2 + 4x$. Find the perimeter.

5. $P = 2x + 2y + 4$. Find the area.

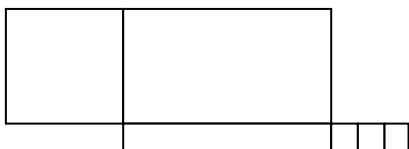
6. $P = 4x + 2y + 4$. Find the area.

7. $A = x^2 + 5x + 4$. Find the perimeter

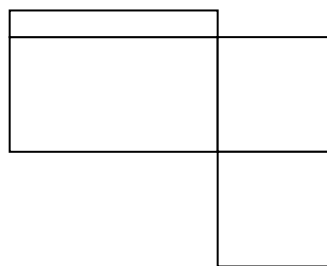
8. $A = x^2 + 4x + 4$. Find the perimeter.

Sometimes customers tell *The Patio Builders* they want patios that are more complicated than just simple rectangles, like those shown below. Place measurements on each side of the patios. Determine a simplified algebraic expression for the perimeter of the figure.

9.



10.

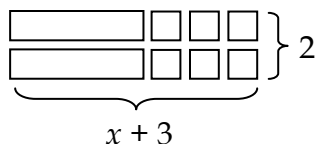


Throw It Into Reverse

On *Patio Plans*, we started with the dimensions of a patio, drew a sketch, and calculated the area. In this activity, we will start with the area, then work backwards to draw a sketch and figure out the original dimensions.

The area of a patio is given below. Use the tile samples to make a sketch, find the dimensions, and find the area. Then show how the product of the length and width gives the area.

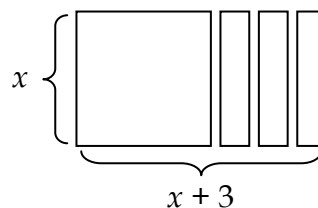
Example 1: Area: $2x + 6$ sq. ft.



The width is 2 ft and the length is $x + 3$ ft.

$$2(x + 3) = 2x + 6 \text{ sq. ft.}$$

Example 2: Area: $x^2 + 3x$ sq. ft.



The width is x ft and the length is $x + 3$ ft.

$$x(x + 3) = x^2 + 3x \text{ sq. ft.}$$

1. Area: $3x + 12$ sq. ft.

2. Area: x^2 sq. ft.

3. Area: $x^2 + 10x$ sq. ft.

4. Area: $2x^2 + 6x$ sq. ft.

In algebra, the process of finding what was multiplied to make a product is called **factoring**. This is exactly what we have been doing in this activity – finding what dimensions for a patio will multiply to give us the area we want. We are *factoring* the area **polynomial** into its two dimensions, length and width.

Factor each of the following *polynomials*. (Remember, this is the same as finding the dimensions of a patio with the given area.) Show a clearly labeled diagram for each to support your answer.

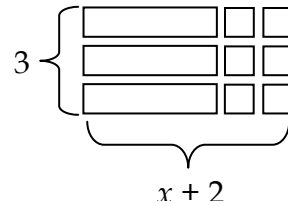
Example 3: $3x + 6 = ?$

Since 3 can be multiplied to make both $3x$ and 6, *factor* out the 3:

$$3(\quad ? \quad) = 3x + 6$$

3 would have to be multiplied by x to make $3x$, and 3 would have to be multiplied by $+2$ to make $+6$, so

$$3(x + 2) = 3x + 6$$



5. $5x + 10 =$

6. $x^2 + 2x =$

7. $2x^2 =$

8. $x^2 + 3x + 5x + 15 =$



9. $x^2 + 5x + 4 =$



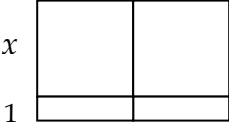
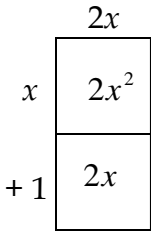
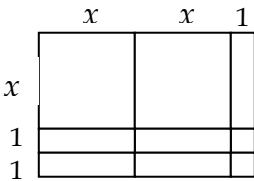
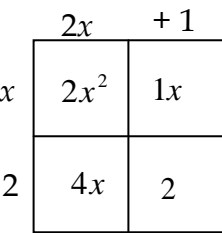
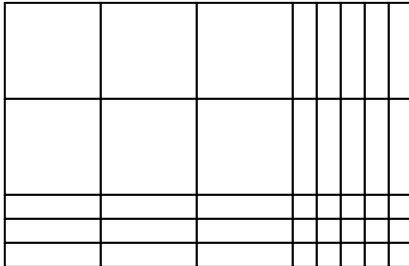
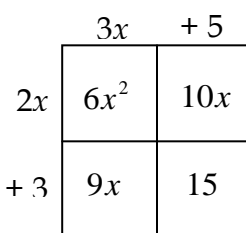
10. $x^2 + 5x + 6 =$



Tic Tac Tile

We have learned how to use tiles to find the area of a rectangle given its dimensions, and how to find the dimensions of a rectangle given its area. Our method is rather cumbersome, though. Let's try a new way that simplifies the diagrams.

Each of these diagrams can be simplified to produce the diagram underneath:

<p><u>Example 1:</u> $2x(x+1)$ x</p>  <p style="text-align: center;">- or -</p>  <p>The total area is: $2x^2 + 2x$</p>	<p><u>Example 2:</u> $(2x+1)(x+2)$</p>  <p style="text-align: center;">- or -</p>  <p>The total area is: $2x^2 + x + 4x + 2$ or $2x^2 + 5x + 2$</p>	<p><u>Example 3:</u> $(3x+5)(2x+3)$</p>  <p style="text-align: center;">- or -</p>  <p>The total area is: $6x^2 + 10x + 9x + 15$ or $6x^2 + 19x + 15$</p>
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Use a table like the ones above to multiply each of the following:

1. $x(3x+2)$	2. $2x(x-5)$
--------------	--------------

3. $(y+4)(y+1)$

4. $3x(2x-4)$

5. $(2z+1)(z+3)$

6. $(3m+1)(4m+3)$

7. $(5x+2)(3x+2)$

8. $2c^2(c+3)$

9. $(p+1)^2$



10. $(3x+y)(2x+5y)$

11. $(2n+1)(n^2+3n+4)$



Patio Tile Samples # 2

x	y
x	y
1	y
1	y
1	y
y	y

From: Robert Robertson,
President
Box It Corporation

Box It Up!

Dear Algebra Students:

We would like to hire your team to develop formulas for use in pricing our boxes. We are undecided whether to price our boxes by the amount of cardboard needed to build the box, or by the volume of the box.

We would like you to develop both formulas. Our company has instituted three types of regularly shaped boxes, which we are calling "Type A", "Type B", and "Type C".

"Type A" box will have the same length, width, and height. In other words, each "Type A" box will be a cube.

"Type B" box will have a length and height that are twice the width.

"Type C" box will have a length 2 inches more than the width, and a height that is 4 inches more than the width.

Our customers will order their boxes by stating the type of box and the width. For example, a customer will ask for Type B, 10 inches. This means a box 10" by 20" by 20".

- Guidelines:
- Customers will order by the box type and the width.
 - Price list fits on one sheet of 11" by 8½" sheet of paper.
 - Price list identifies all three standard box types.
 - Price list shows a picture of the box types.
 - Price list identifies the prices of some standard sizes of each box type (widths of 8", 12", 16", 20", and 24").
 - Price list gives a formula (in terms of the width) which can be used to determine the price of any box.

- Prices:
- When pricing according to amount of cardboard, calculate at \$0.003 per square inch.
 - When pricing according to volume, calculate at \$0.0015 per cubic inch.

Provide an explanation sheet for Mr. Robertson to give to new employees which shows how you determined the prices.

Sincerely,

Robert Robertson

Box It Up! Activity**Name:** _____**Google Your Math Unit Project for Polynomials**

The class received a letter from Robert Robertson, the President of Box It Up Corporation, to create and organize a price list for the cardboard for various sized boxes. The information below states the types of boxes and the price per box if calculated using area or surface area. Use the information from the Letter to fill in the box shapes and dimensions:

Box Type	Box Shape	Length	Width	Height
Type A				
Type B				
Type C				

Pricing:

Mr. Robertson wants for us to identify the price for box types with widths of 8", 12", 16", 20", and 24".

To find the cost of cardboard use the following:

1. Costs \$0.003 per square inch
2. Costs \$ 0.0015 per cubic inch

To complete this project, you should reply to Mr. Robertson with an organized list for both methods of pricing cardboard. Your reply should include an explanation of your work and your recommendation of whether they should charge by the square inch or cubic inch.

Activity: To run simulations to help you begin, follow the directions below. Record all your information in the Google Spread Sheet that is shared with the class in Google. (Sample)

Team Member	Box #	Box Type	W	L	H	Volume	Surface Area	Cost \$0.0015 cu. in.	Cost \$0.003 sq. in.
Diamond									

Directions:

1. Roll a die. Let the number determine what box type as follows: 1-2 = type A, 3-4=type B, 5-6=type C.
2. Roll the die again. Multiply the number by 4 to determine the width of the box in inches.
3. Use the information given above about each box type to determine the length and height of each box.
4. Find the volume and surface area for each box.
5. Calculate the cost of each box by both the cubic and the square inch.
6. Each team member is responsible for inputting and calculating the data for their particular box.

Data Sheet: Complete your work below.

Sketch Box 1 Type: _____	Sketch Box 2 Type: _____
--------------------------	--------------------------

<p>Box 1 – Show all steps</p> <p>Width:</p> <p>Length:</p> <p>Height:</p> <p>Volume:</p> <p>Surface Area:</p>	<p>Box 1 – Show all steps</p> <p>Width:</p> <p>Length:</p> <p>Height:</p> <p>Volume:</p> <p>Surface Area:</p>
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<p>Costs Box 1</p> <p>Cost by Volume (\$0.0015/cu.in.)</p> <p>Cost by Surface Area (\$0.003/sq.in.)</p>	<p>Costs Box 2</p> <p>Cost by Volume (\$0.0015/cu.in.)</p> <p>Cost by Surface Area (\$0.003/sq.in.)</p>
---	---

Box It Up!

Plan Sheet

To complete this project, you must perform the following tasks:

Create a price list to meet the following guidelines:

- The price list fits on one page – submitted electronically on either a Google Document or Spreadsheet (shared with your team and your teacher).
- The price list identifies all three standard box types
- Shows a picture of each box type – (this can be hand drawn or drawn on a computer)
- Identifies the prices for the following standard sizes for each box type with widths of: 8" 12" 16" 20" and 24"
- Gives a formula (in terms of the width), which can be used to determine the price of ANY box using either surface area or volume. Make sure to multiply completely.

The Plan: You and your team must complete this project this week for your homework. In order to assure that everyone participates, you must post all evidence of your work on Google. Here are some ideas:

1. Create a Google Doc and Google Spreadsheet and share it with everyone in the team (and your teacher).
2. Use the Google Doc to post work that you have completed and to document your planning and accountability.
3. Use the discussion to ask questions to peers outside of your group.
4. Use the Google Spreadsheet to organize and complete your work.
5. Submit the completed assignment by Friday.
6. You will be graded on accuracy, completion and on your team's online participation.

Due Date: _____

20 points per student.

Algebra 1

Name: _____

*Google Your Math***Post Assessment – Box it Up!**

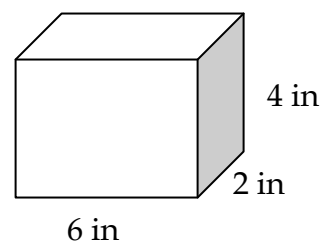
Answer the following questions to the best of your ability. Your work will be scored using the rubrics listed below on the back. Do not leave problems blank.

Use the following rubric for how you will be assessed.

Conceptual Understanding	0 points – no explanation 1 point – explained an incorrect process 2 points – explained a correct process
Procedural Fluency	0 points – did not try or used an incorrect procedure 1 point – used a correct procedure but made errors 2 points – used a correct procedure with accuracy

5. Given the rectangular prism at right, calculate the following.

a. Calculate the volume (procedural fluency).



b. Explain your solution completely (conceptual understanding).

6. Use the same rectangular prism to answer the following.

a. Calculate the surface area (procedural fluency).

b. Explain your solution completely (see for conceptual understanding).

7. Given $3x(4x^2 - 5x - 7)$.

a. Find the product (procedural fluency).

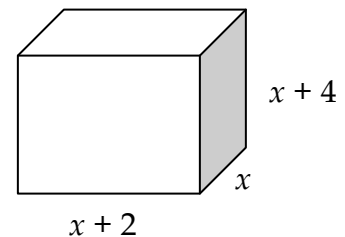
b. Explain your solution completely (conceptual understanding).

8. Given $(3x + 2)(4x^2 - 5x - 7)$.

a. Find the product (procedural fluency).

b. Explain your solution completely (conceptual understanding).

Challenge Problem: Given the rectangular prism.



c. Calculate the volume (procedural fluency).

d. Explain your solution completely (conceptual understanding).

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