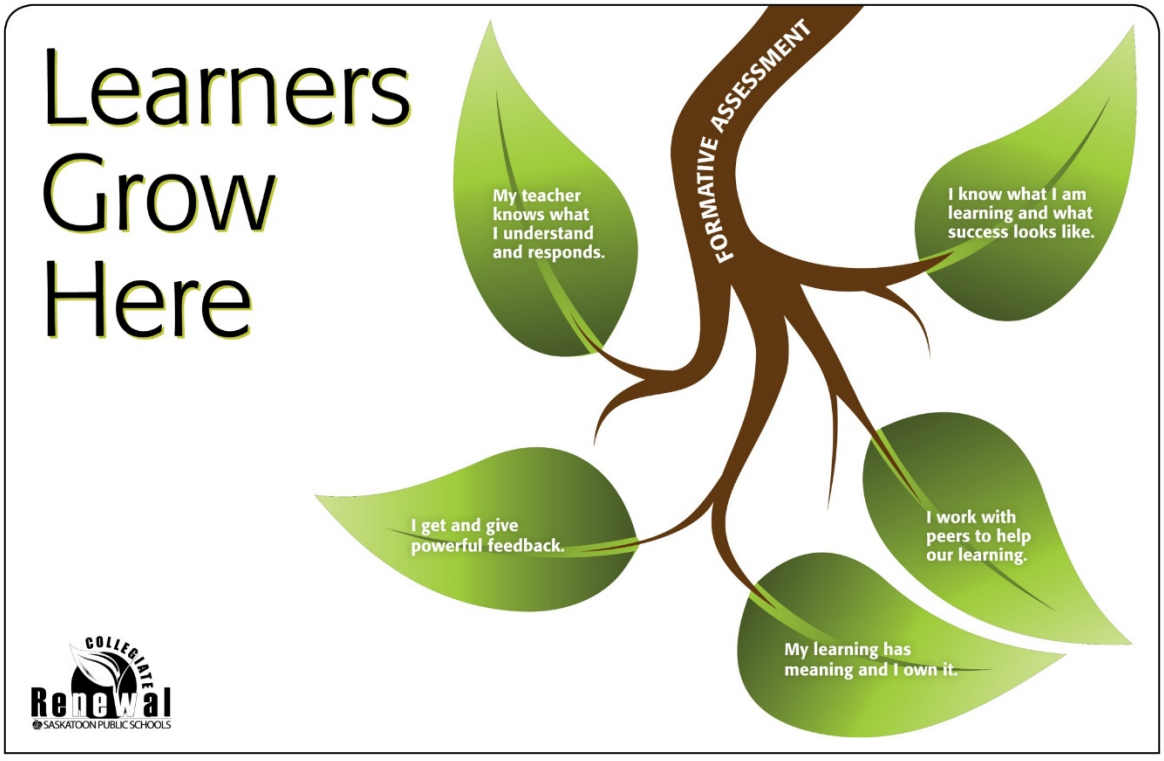
2014

Developing Competence and Potency in Grade Nine Math Students: Math 9+

a nomination for the Premier's Board of Education Award for Innovation and Excellence in Education



School Division: Saskatoon Public Schools

Chairperson: Mr. Ray Morrison

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Introduction

As Saskatoon parents watch their children transition from elementary school to high school, they want to see their children happy and growing. They imagine teachers who know exactly who their children are as individuals, and instruction that responds to their specific instructional needs. For the children and parents who are facing difficulties in math, the fear of repeating classes or failing to graduate on time looks large. While administrators and mathematics teachers know passing math is important, they also understand that math is a subject where every gap or problem in understanding gets compounded with each new class. For those educators, the critical issue is not passing, it is competence with mathematics and a student's sense that they can "do math." Success in Grade 9 Mathematics is critical in transition, and the last chance to ready for high school math credits in Grade 10. Three years ago the Saskatoon Public School (SPS) Board of Education directed high schools to address transition into high school mathematics, and teachers and consultants created Math 9+.

What makes Math 9+ so unique is the intimate relationship between assessment and instruction throughout the entire program. Students' strengths and gaps in K-8 Mathematics are assessed before teaching begins, and constant assessment and instruction drives daily activities. As result of the course, students feel a sense of accomplishment when they finally understand concepts they have struggled with for years. Student confidence, self-efficacy, and competency are built every day as assessment *of* and *for* learning are paired in an instructional loop called responsive instruction. Students call the class "super helpful" and teachers describe as critical in closing the achievement gap in mathematics.

Role of the Board of Education

The SPS Board takes an active role in both prioritizing the learning agenda and analyzing results. A decade ago, the Board determined that efforts for educational improvements were too diffuse, resulting in lack of clear progress. Over the next several years the Board identified two key learning priorities, literacy and engagement in high schools. To keep the work focused, the Board hears four quarterly reports about the actions of teachers and professional developers, and looks at a wide variety of data including literacy assessments, student engagement results on national assessments, standardized achievement results in math and writing, and a variety of school specific results including measures like attendance, retention and credits attained in high schools. They also asks for regular summaries about the actions and their impacts in a yearly formal report.

Goals within the Board's Priorities

SPS is proud of the work happening through its two Board learning priorities *Literacy for Life* and *Collegiate Renewal*. The primary focus for in Collegiate Renewal, engaging secondary learners, centers around four key elements: belonging, potency, competence, and relevance. While all four of these are addressed by Math 9+, competence and potency are the key goals, as they are critical for successful transitions in Math.

Competence

Competence is central to learner engagement in all subjects. The development of key competencies is both an end in itself (the goal) and the means by which other ends (or goals) are realized. Challenge within competencies is also a powerful motivator. Engaging work is *learning* that is *just* outside the zone or reach of students. It is the space between what students can do independently and what they can do with teacher help (Vygotsky, 1978). For students with gaps in mathematics, competence becomes increasingly elusive when they miss knowledge and the new learning becomes too hard.

Potency

Potency means "to feel able." Such a feeling comes in having influence over one's learning, in having a strong sense of self-efficacy or belief in one's own abilities, and in believing what has or is being learned is worthwhile or significant. In mathematics, a student needs to think "Yes, I think or feel I can do this."

Complex Need for Innovation

Math 9+ as a concept was generated by the math teachers and consultants of Saskatoon Public Schools as a response to students who were struggling in a successful transition into high school mathematics. As a group, the teachers determined common issues they were seeing and discussed what they might focus on to better meet the needs of the students.

Firstly, the teachers observed that some students have gaps in their understanding due to school disruptions, memory, or inability to comprehend complex ideas. If a student is missing a concept in math or just learned a process without understanding the mathematical concept, a student cannot build new knowledge on this prior learning. In addition, it becomes more difficult to remember what was learned because it cannot be retrieved as readily without a conceptual framework. As learners move up, grade level understanding might require background knowledge in four to six prior areas of learning. "The importance of mastery of prerequisite skills prior to moving on to the higher-level skills cannot be overstated" (Bender, 2009, p. 6).

The next major issue is *memorization* rather than *automaticity*. For some areas in math, a student needs such a strong level of memory that doing a task requires no thinking. In other words, the student can use the math fact, process, or algorithm fluidly while concentrating elsewhere: "'Research has demonstrated the critical importance of automaticity in math facts as one critical basis in increase achievement in higher mathematics' (National Mathematics Advisory Panel, 2008; Woodward 2006). Students can proceed successfully in math only after the math facts are learned at the highest level" (Bender, 2009, p. 13). A student who has memorized times tables or does not know base ten spends too much time retrieving mathematical concepts and must think too much about how apply each skill. *Computational fluency* requires that you both understand what something is and how you use it.

Some students take more time to process mathematical thinking. They need this time to fully understand and to make the level of challenge appropriate. They also benefit for opportunities for reflection. The need for purposeful practice is a critical part of managing instruction for students who need more time. A specific need is identified by the assessment, then instruction is provided to achieve clarity, and finally, a student practices. This insures that all practice is rehearsal of a correct concept rather than an error, and provides the opportunity to practice enough that the concept or procedure is fully understood. During the practice, there is persistent assessment and additional instruction so the amount of practice is individualized. This means students who take more time use as little time as they can while still understanding deeply.

In the first year, teachers informally identified students who might have these issues. By the 2012-13 school year, formal screening processes and a common teacher-made diagnostic assessment were in place. Administered at the start of Grade 9 as a pre-assessment, the assessment revealed areas of serious concern. Of the 241 identified students who wrote the diagnostic at the start of the 2013-2014 school year, the diagnostic found, for example, that almost all the students were missing whole number concepts from Grades 5 and lower (see Appendix B). Being unable to add, subtract, multiply, or divide whole numbers is an absolute barrier to working in different number systems and contexts.

Innovative Nature of the Response - the Structure of Math 9+:

Math 9+ is designed to help students fill gaps in mathematical skills and understanding so that they can experience success in high school mathematics (see Appendix A). This is done through a mastery learning approach, combining additional instructional time, additional teacher support, a continuous pre-assessment/ instruct/practice/post-assessment cycle (see page 7), and specific strategies and resources meant to target foundational math skills and concepts.

A student gets a placement in Math 9+ depending on a combination of academic history, transition meetings, observations of Grade 8 teachers and parents, quantitative data points, and student scores on the diagnostic assessment. Like the admissions process, each stage of progress in Math 9+ is driven by multiple data points about the student's current success. Our Board continues to emphasis data-driven decisions, and the learning agenda is

focused there. Through many checks on student understanding, called formative assessment, Math 9+ meets a student's needs.

Math 9+ is an individualized process for each student. Prior to starting Math 9+, a student completes a diagnostic that highlights areas of strength and areas of concern. The division endeavours to have smaller class sizes and two teachers, so that each student can be supported in moving through the units. Math 9+ uses the support of both a resource teacher who understands learning disabilities, and a math expert with content and pedagogy. Written materials, manipulatives, videos, and specific, small group or one-on-one instruction are used to help students progress rapidly through ideas they deeply understand and gain mastery of concepts and process they have not yet be successful with. Issues are discovered quickly, and there is an immediate instructional response.

In traditional math instruction, a teacher models a concept, students practice the concept, and then they are given a summative assessment. The foundation of Math 9+ is many iterations of formative assessment and instructional responses. Before the class even starts, a diagnostic assessment determines the unit at which the student will begin. Pre-assessment for a unit, then instruction, then practice occur. If a student still struggles in any area during practice, error analysis and re-teaching using a new instructional method occur before the student tries a post assessment. Once mastery in a particular unit is achieved, the student moves on to the next unit. A more complete description of the innovation and the instructional approaches is found in Appendix C.

Improvements in Student Achievement

Students value increased feelings of self-efficacy and competence

Teachers use interviews, Learning Logs, a formal exit interviews and/or journals to assess students' ability to understand their own learning, assess it accurately, and feel potent as mathematical thinkers. Students were asked to discuss the strengths of Math 9+ or how it made them feel at the end of year. The following are samples from a class at a school that admits many struggling math students at the start of Grade 9, reflect the goals of the program. The student voices in these first few years underscore the value of support, time, flexibility, and appropriate challenge:

- "Well, this class is very helpful if you are struggling with math. It helps you however you need it. My advice is to get all of your work done as soon as you can, because it pays off in the end."
- "It makes me feel a lot more confident about my math skills."
- "In Math 9+ I learned that even if we are all in the same grade, we all have different math levels. In Math 9+ it makes me feel like I am not the only one in the math level I should be in. What I liked about Math 9+ is that I got to review the things I kind of misunderstood in previous years."
- "Math 9+ makes me feel like I learned what ***I*** needed to learn. What I liked about Math 9+ was that I had a lot of help to complete my math."
- "My confidence for going in Grade 10 Workplace and Apprenticeship is high after getting help from Math 9+."
- "Math 9+ makes me feel better about my math."
- "I liked the independence of being able to go at my own pace. I liked that I had 2 semesters to work on math instead of 1, because it is harder for me to learn when everything is piled into one semester."
- "Math 9+ is helpful, and it is easy to ask questions."

A year after Math 9+, our first cohorts of former students can articulate the value even more clearly, as seen in the transcription of student responses in this interview with two Grade 9 students:

> Student 1: "It was fun, and it made me more confident in my math because I used to be really nervous going to class and now I feel more confident and everything's easier."
>
> Student 1: "I feel way more confident now. Like, at first, I would be like, oh my god, I'm never going to get into Grade 12 Math even, but now, like, I know that I can do it."

Student 2: “We are doing tangents in our new Grade 10 class. Even though we didn't do stuff like that, we did Pythagorean Theorem, and you can use that with tangent. And I was actually one of the people who was speaking the answers today in class. I was quite proud of myself.”

Student 1: “It just makes math easier and more fun. I usually would have been the kind of person to say, "Okay, I'm skipping math for today - I'll just work on it at home"... now I'm fine going to math. I actually feel happy going to math, and I have fun with my friends, and, like, I know what to do. I've helped, like, so many people. And it's like "I came from Math 9+, but I can still help you.”

Student 2: “When we walked into Math 9+ the first time, you feel, kinda, well, not stupid, but, you know, you think "If only I was in the normal Grade 9 class." But now, thinking back, if I had been in that normal Grade 9 math class, I probably would not have even made it to Grade 10. Because with Math 9+ it helps you fully understand … it’s more individual and you move at your own pace, which makes it so much easier."

Student 1: “I remember first semester of Grade 9, we walked into science class and we started out with a lot of math and stuff. I was freaking out and I didn't know what was going on. But then, by like the third month of taking Math 9+, I knew everything and I was a lot more confident. It helps you with other subjects too.”

Student 2: “Even if you don't understand a question in a new class, I still know from Math 9+ how to work through that question. And then from that I can get the answers.”

Student 1: “At first I regretted it [signing up for Math 9+], and I thought maybe I should have signed up for a "normal" math class. It was so weird telling people I was in Math 9+ because everyone saw it as "stupid math" but they don't realize that it makes you like ten times smarter than them. It actually does. Some of the people who used to call me dumb from being in it, I've actually been helping.”

Student 2: “People who were in the traditional math class who are in my Grade 10 math class now, will come ask me for help because they don't understand it.”

Student 1: “I love Math 9+ so much and I don't regret it at all.”

Student 2: “What she said!”

Feelings of increased self-efficacy are also associated with reported engagement in a subject area. Math tends to be a polarizing area, where students report they love or hate math, but are rarely indifferent. In our 2013-14 *Tell Them From Me* (TTFM) student survey results, our Grade 9 students reported feeling a high level of engagement in mathematics at a rate that was 16% higher than the national average. We feel confident that our work on engagement through the Collegiate Renewal initiative and our support for struggling students have impacted their feeling of engagement with mathematics.

Appropriate Challenge

Because we were using a responsive instruction cycle to try to place mathematics instruction in each student’s zone of proximal development, another key measure is student reported levels of appropriate challenge. Although our results in 2013-14 *Tell Them From Me* cannot be disaggregated by grade, we are delighted to report that the level of appropriate challenge in our math classrooms are 21% higher than other divisions with similar student populations.

Impacting Students’ Comprehension to Improve Achievement

Pre- and post-survey result revealed improvements in student’s ability to complete the diagnostic with grade level skills. In the pre-survey, more than 95% of the identified students struggled with questions that required whole number operations. Because of the mastery approach to the units, 100% of the student in the post survey demonstrated appropriate understanding of whole number operations (see Appendix B). Positive results were found in other units when the pre- and post-diagnostics were compared. For example, the operations post-test data indicates that students have must stronger sense of the concepts they will need to be successful in high school math (see Appendix B). While these results are preliminary, they are promising.

The success with the Math 9+ students may also be impacting the division's overall results in math. Over the two years of wide scale use of Math 9+, the division also saw an improvement in CAT4 (Canadian Achievement Test, version four) test results in mathematics. Previously, SPS students performed slightly behind the bell curve on overall mathematics results, but now preform slightly ahead at the Grade 10 level in just two years. The Math 9+ cohort primarily influenced stanines 1-4, where the greatest gains are visible. Perhaps the most exciting element is the comparison between the pre-Math 9+ results and our results last year. The number of students in stanine 4 or above in the overall mathematics score is now six percent higher than it was prior to the intervention.

Successful Completion of Grade 9 Math

In 2013-14, we had 1506 students taking Grade 9 Math, 177 of whom were in Math 9+. Prior to large scale implementation of this support 10% of students in the division failed math in Grade 9; in 2013-14, only 3% failed. In addition, the overall marks for Grade 9 Math in the division have risen steadily over the length of the initiative. While these results are largely the result of Math 9+ using a mastery learning model and not assigning a percentage grade, there have been promising and positive changes to success rates as the students move into Grade 10.

Success in Grade 10 Math and Opportunity in Post-Secondary

In the past many students who had barely passed Math 9 struggled to complete the Grade 10 Pathways. However, the 2013-2014 results indicated a change in this pattern. When the Math 9+ cohort moved into Grade 10, 33% took Math Foundations and Pre-Calculus (FPC) 10, and 46% took Workplace and Apprenticeship (WA) 10. In the 2013-2014 school year, only 12 of the former Math 9+ students failed a regular WA 10 and only 6 failed a regular FPC, indicating much higher levels of success for those students who were identified as struggling the most coming into Grade 9. Clearly, Math 9+ is improving the results as students move into Grade 10. To illustrate, only 58% of Grade 10 students took FPC in 2010-2011 prior to the initiative, and 13% of those students failed. In 2013-2014, 1,599 students, or 73%, took FPC, and only 7% of the students who took the class failed it. Many of the struggling Math students could not complete FPC prior to Math 9+, but our preliminary results now indicate that most Math 9+ graduates complete it successfully.

Evidence of Direct Board Influence and Participation

Three years ago, the Board looked at results in mathematics and asked schools to address instruction in this area. A number of specific changes were made over the next three years including asking elementary schools to add a mathematics goal to their strategic planning, increasing funding for professional learning around math, appointing a Coordinator and Superintendent with specific responsibility for math, and building the transitions program called Math 9+. At the end of last year the Board refreshed the learning priorities, called *Literacy for Life* and *Collegiate Renewal,* so that the literacy priority also addressed mathematics and *Collegiate Renewal* focused more directly on competence.

Math 9+ has been highlighted during a Public Board meeting as a Core Strategy update and the Board has considered data compiled data to support the program. Under the renewed mandate from the Board, administrators at both the elementary and secondary level have received information and professional development on the goals and structure of the Math 9+ program. The Board continues to ask specific, powerful questions about the measures being taken to improve results for students.

Costs and Sustainability

There were 20 sections of Math 9+ in 2013-2014. Although this meant increasing the number of math sections, the students take the same total number of courses. While the cost per student is the same in terms of the overall minutes of instruction, more student time is spent learning math.

Having a second teacher assigned to the class meant a reassignment of resources, not additional resources. As well, in many high schools, a substantial amount of resource time is dedicated to helping students be successful in mathematics, so much of the time from the additional resource teacher is simply a different placement during a period, rather than an additional cost in hiring a resource teacher. In many situations, our collegiate resource teachers work as co-teachers in a variety of courses. In addition, while two teachers is optimal, not all classes last year had two, or they may not have had two for the entire year.

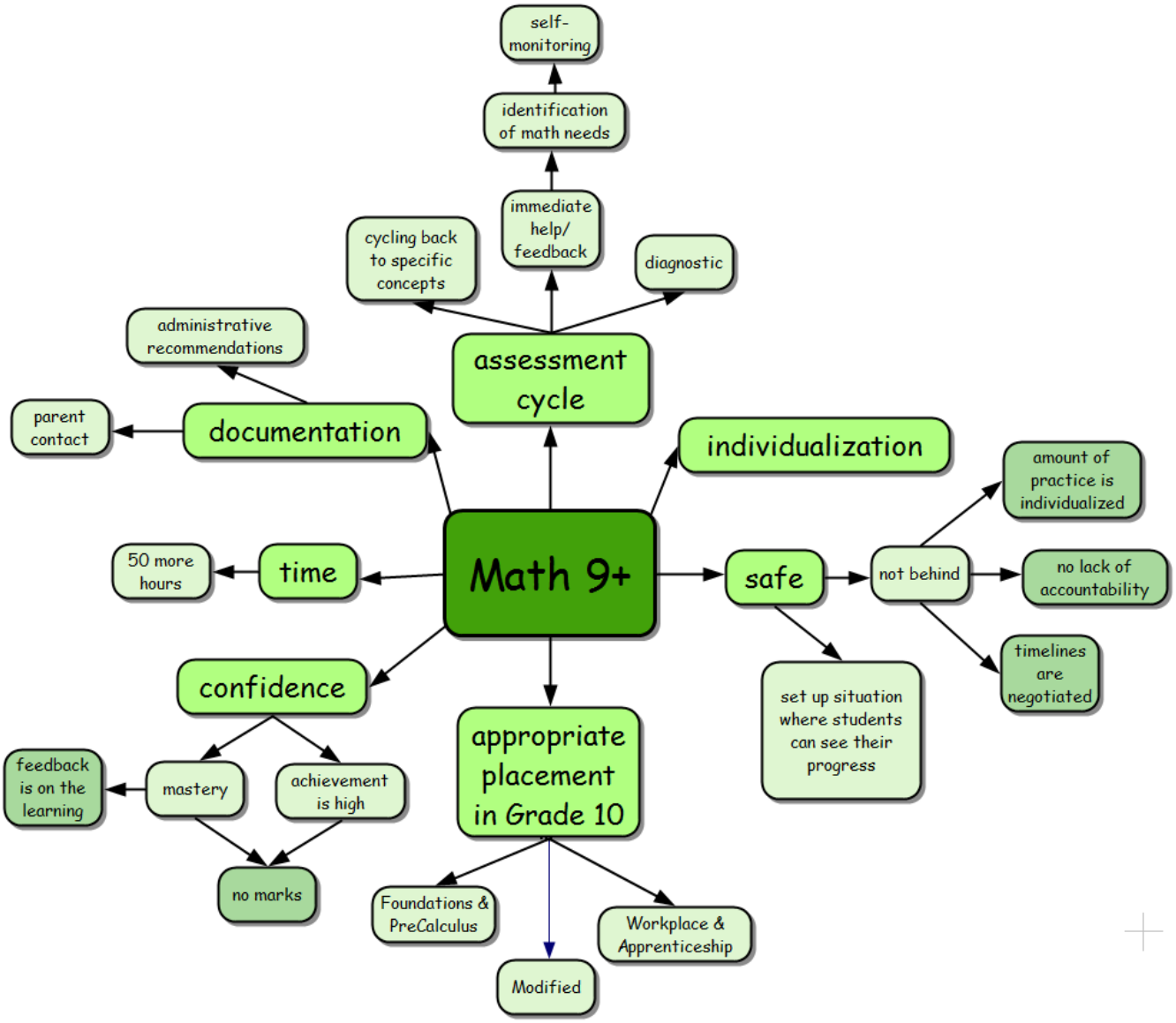
Early results indicate that the extra time devoted to math in Grade 9 is offset by the cost associated with a failed course. This year, there were approximately two extra sections of students (3% or approximately 44 students) across the division who needed to retry Math 9. In the past, the number of students who repeated Math 9 required between five and six additional sections. In addition, many of these same students failed at least one math course in Grade 10 and beyond, leading to both more math sections and more sections of resource supports dedicated to supporting students in math. Students who close those gaps in Grade 9 require fewer interventions throughout high school and have more options to take electives related to personal interests and potential career paths.

Conclusion

> *"For many of students, this is the first time that they have EVER had success in mathematics. It is an invitation back to mathematics, and all of the potential that comes with that. In the end, this program offers students hope. Not a false hope, but a real, authentic hope based on real competencies for those who have long struggled with mathematics. It is an "on ramp," and we will always need programs like this to allow students who are willing and just need the opportunity to get back to learning mathematics." (*Janelle Tang, Math 9+ teacher)

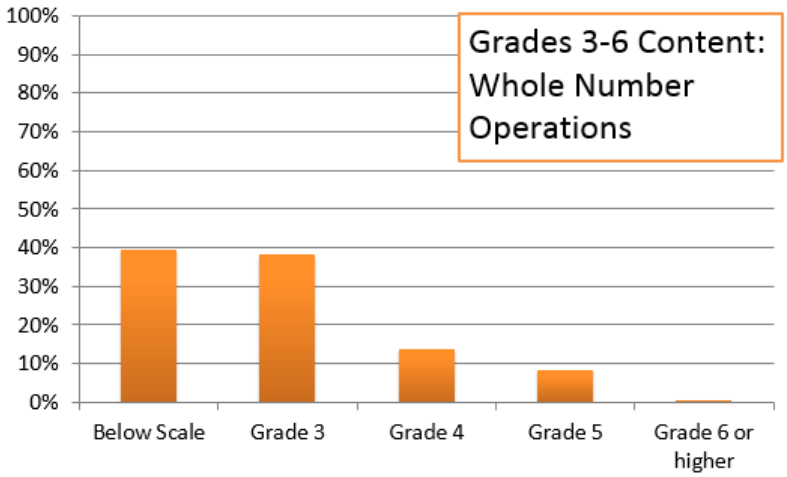
We are proud to nominate Math 9+ for the Premier's Board of Education Award for Innovation and Excellence in Education. Through the unwavering support of our Board of Education, who are laser-focused on student achievement and success, Math 9+ has shown early success in helping students who struggle with math. In the two years Math 9+ has been in collegiates, it has supported students to build competence and potency through mastery of foundational math skills. Through the leadership of our Board of Education, Math 9+ has inspired Grade 9 students and families and given them hope; they can build on their positive Grade 9 Math experience and make more informed decisions as they plan for future secondary math classes and post- secondary or career opportunities.

Appendix A – Key Features of Math 9+

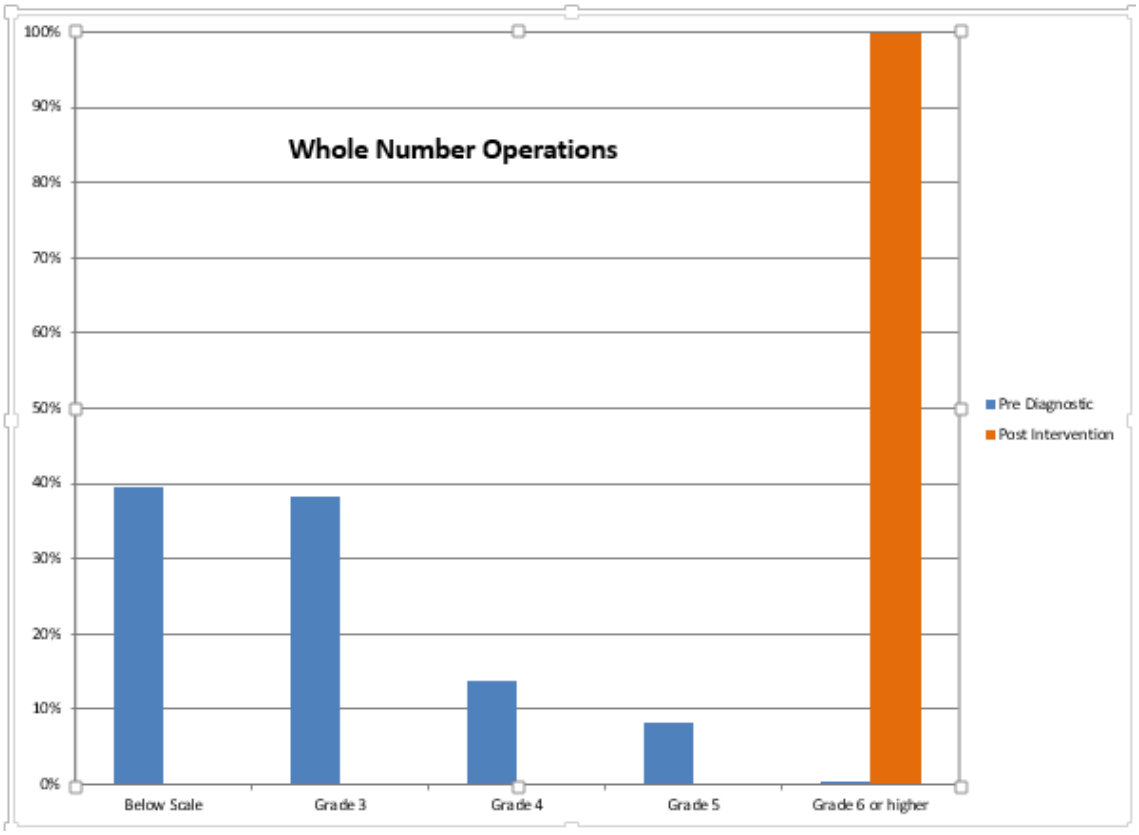


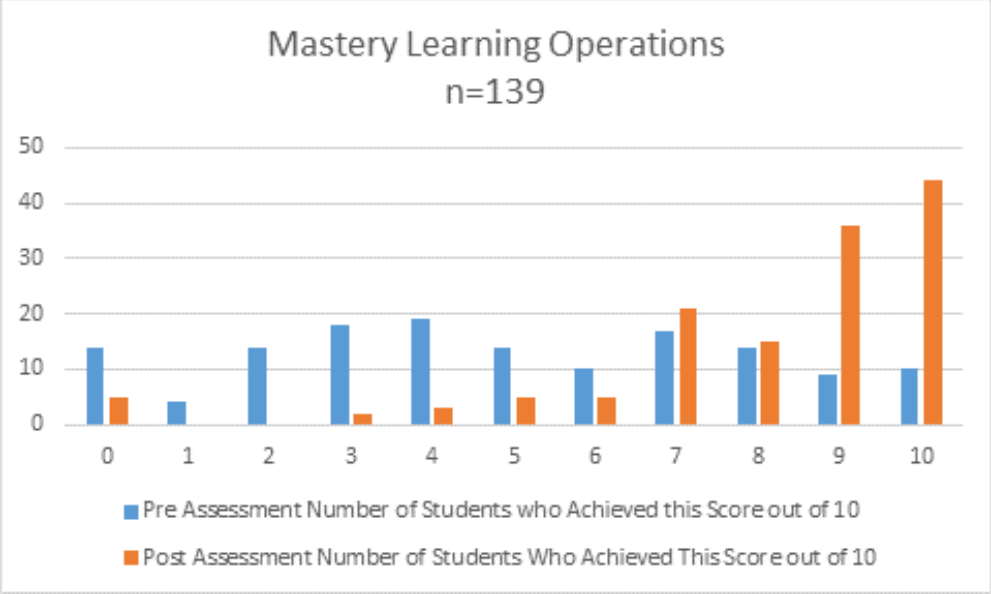
Appendix B – Pre and Post Survey results

Prior to Math 9 plus many student experienced understanding gaps that placed them below grade level on key math concepts and skills.



After the initiative, a post test of those same students revealed that students now had the necessary skills for success in some of the key ideas tested.




Mastery Learning Operations
n=139
50
40
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20
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8
9
10
Pre Assessment Number of Students who Achieved this Score out of 10
Post Assessment Number of Students Who Achieved This Score out of 10

Appendix C – The Classroom Process of Math 9+

As a division, we have focused our professional learning efforts in the last several years on formative assessment (Assessment *As* Learning and Assessment *For* Learning combined). Because Math 9+ is designed support learners who have struggled, providing them with the most effective instruction is essential. Since we know this instruction is informed every day by formative assessment, conducting effective formative assessment and responding immediately is the heart of the program: "There is a 70% increase in how quickly students understand the important ideas in the classroom when formative assessment practices are integrated into the minute-to-minute and day-by-day classroom activities of teachers" (Leahy and Wiliam, 2009, p. 15).

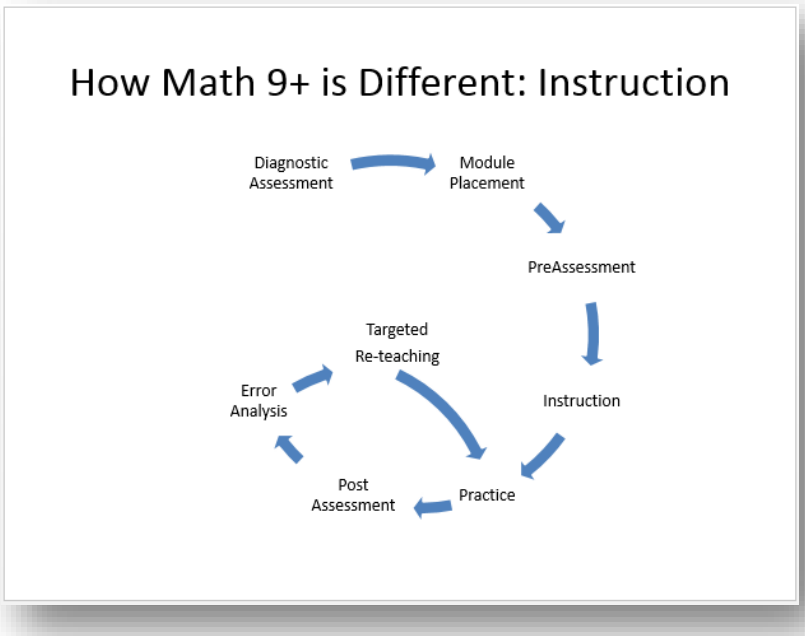
The resources and instructional processes for Math 9+ focus on tasks that elicit evidence of learning. These tasks, which included pre-assessments, checkpoints, and key questions done on white boards have several key characteristics:

- They are focused on the learning outcome
- They occur as students are learning, not at the end of the day or the end of the sequence of lessons
- They take little time to conduct and assess
- They are not graded
- Teachers use what they find from the quick check to adjust what they teach next for each student

Teachers receive a variety of supports to help them with the eliciting evidence of learning in addition to their regular school-based professional learning. They have monthly meetings of the Math 9+ Learning Community where they learn new strategies and make decisions and problem solve together. They also have a variety of online materials for professional learning, consistencies of practice, and a set of print materials, mini-white boards, and manipulatives for use with students.

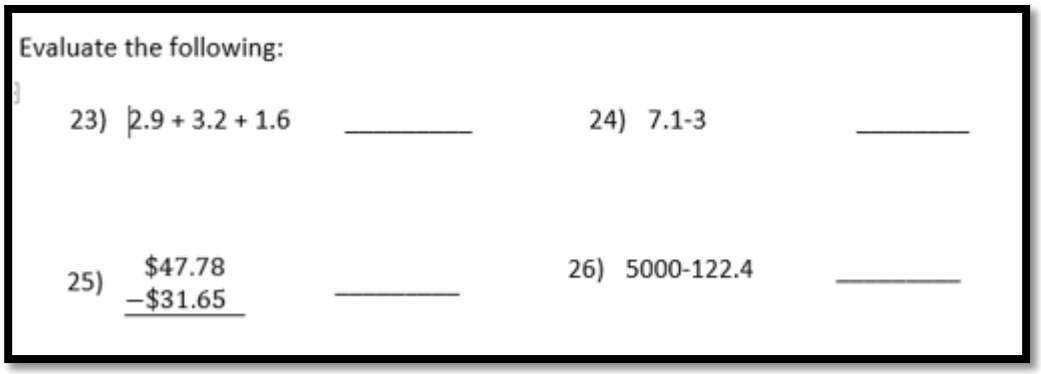
Like eliciting evidence of learning, the activation of learners as owners of their own learning is key. Teachers use journals or Learning Logs with students so that they reflected on their accomplishments, identified areas for growth and goal set. In addition, formal and informal questioning is used to encourage students to approach their learning with a growth mindset. Effort to overcome barriers and new successes are the focus of conversation in order to create a strong sense of self-efficacy in the students.

The Mathematics Nine Curriculum confirms the need for student self-reflection and goal setting is critical in trying to address the exact learning need of each individual student: "Self-reflection, both shared and private, is foundational to students developing a deep understanding of mathematics. Through reflection tasks, students and teachers come to know what it is that students do and do not know. It is through such reflections that not only can a teacher make better informed instructional decisions, but also that a student can set personal goals and make plans to reach those goals" (p. 22).



Pre-assessment diagnostics

Administered in the fall of each school year, the pre-assessments are uniquely designed to help a teacher determine what gaps or misunderstandings students might have. For example, consider these questions related to decimals:



The above questions were purposefully chosen to reveal the depth of student understanding of the addition and subtraction of decimals. They also facilitate the exposure of possible misconceptions. Questions are displayed in both a vertical and horizontal format. The use of the number 5000, in question 26 requires the students to input the decimals. In question 25, the dollar sign is inserted to reveal if students can subtract if they think in terms of money. All of the questions provide much more than the knowledge of whether or not students can get them right or wrong. They provide important "clues" about where to begin instruction.

Daily Assessment For Learning

Often students complete work on mini white boards allowing teachers to see multiple students' responses easily or in larger form. This allows teachers to see errors as students are practicing and help students see their own calculation errors and misunderstandings. In addition, there are regular checkpoints where students complete a small number of questions, check their own work, and identify their own errors. The students help themselves, and then teachers intervene. Checkpoints occur before practice in order to ensure students understanding. Since practice is used to crystalize student understanding and rehearse it in order to add it to long-term working memory, it is very important that students do not practice and remember misconceptions. Perfect practice is much more successful in helping students understand, remember, and use their math skills: "Practice may not make perfect, but it does make permanent, thereby aiding the retention of learning. Consequently, we want to ensure that students practice new learning correctly from the beginning" (Sousa, *How the Brain Learns Mathematics*, p. 62).Once students have completed the practice, post-assessment provide a final opportunity for intervention.

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