Teaching Mathematics in a Changing Classroom

By

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Dedication

I dedicate this project to my husband and my sons, who have provided the love, support and encouragement I needed to travel this journey.

Abstract

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Mathematics has been the subject of debate for over a century. Establishing a curriculum that adequately prepares students for the future and providing instruction to ensure student success, was problematic in the past and continues to impede current reform. By reviewing the history of mathematics reform in North America, factors that prevent sustainable, system wide change, can be identified. Many of the difficulties that were encountered in the past, continue to be issues in the mathematics classroom today. In addition, present-day classrooms are inclusive and becoming increasingly diverse. This paper proposes a plan that includes collaboration, shared vision, professional learning and communication with all stakeholders, within an instructional leadership framework, to reform current instructional practices in mathematics.

Table of Contents

Chapter 1

Mathematics curriculum has a long history of reform initiatives and debate (Ball, 1993; Davison & Mitchell, 2008; Klein, 2003; Schoenfeld, 2004). The conflicts in mathematics education can be "best understood as a protracted struggle between content and pedagogy" (Klein, 2003, p. 2). Since the early 1900's educators disagree on the mathematical content to be taught and the way it should be instructed. "If content decisions come first, then the choices of pedagogy may be limited . . . in the same way, [that] the choice of a pedagogy can naturally limit the amount of content that can be presented to students" (Klein, 2003, p. 3). In an effort to modernize mathematics in the early 1960's, many reformers viewed the initiative as simply including their 'new math' syllabuses in textbooks and providing them to teachers (Kilpatrick, 2012). "The 'new math' curriculum changes were not accompanied by larger systemic changes, and were thus judged as failures" (Kilpatrick, 2012, p. 569). "It was a top-down reform, initiated by the mathematics community, without buy-in from teachers or the public" (Davison & Mitchell, 2008, p. 147). By the 1970's, the 'new math' era was dead and mathematics education went back to the basics (Klein, 2003; Schoenfeld, 2004). In 1989, the National Council of Teachers of Mathematics (NCTM) published the Standards for School Mathematics (the *Standards*) to guide revisions to school mathematics curriculum, influencing the current reform initiatives across North America. The successor, NCTM (2000) Principles and Standards for School Mathematics has become one of the most significant reform documents in the United States and Canada. Reform has called for changes to teaching practices (Schoenfeld, 2004), that may seem "alien to people who have experienced mathematics instruction only in traditional ways (Schoenfeld, 2004, p. 272). Unlike the initiatives in the past, teachers have been identified

as the key component to sustained reform (Brazer & Bauer, 2013; Drake & Sherin, 2006; Kilpatrick, 2012). The "challenge becomes creating classroom practices in the spirit of [reform] ideals" (Ball, 1993, p. 273).

This project began with a reflection of my own teaching practices in mathematics. Time and time again I encounter students in grade six with the predetermined mindset that they "suck at math". I never looked at myself as having an aptitude for mathematics until I was in University. I soon realized that what appeared to me as simple logic had others tearing out their hair in frustration. The hope for me was to have students enjoy math as much as I did. In an effort to increase student understanding and achievement in math, I worked to provide lessons that would develop a solid foundation of basic numeracy skills in my students. In my mind, building a solid foundation for my students would be beneficial for learning and understanding more complex mathematics. In 2008, Alberta Education changed the mathematics curriculum and implemented it over the next four years. At the time it was first released I was teaching grade one. My assignment changed the next year to grade three and again four years later to grade six. Teachers were encouraged to change their practices to encompass a student-directed learning environment and new textbooks were purchased. I attended professional development opportunities that were made available, but struggled with implementing the new innovative and creative ideas in my daily lessons. I was being asked to create, develop, and implement math lessons in a way that was unfamiliar. I worked diligently to provide students more opportunity to use manipulatives and cut out some of the 'worksheet' style activities I had used in the past. After seven years, I continue to fall back, as a last resort, on more traditional styled teaching, especially when I am faced with PAT's (Provincial Achievement Testing) in early June. In Alberta, elementary students in grade six must write the PAT for math in the middle of June.

Until a year ago, grade three students also wrote PAT math tests in June. Currently Alberta Education is developing SLA's (Student Learning Assessments) to replace the PAT. In some cases, depending on the diversity in the classroom, it becomes a race to finish the curriculum in time for review. Some students manage fine while others struggle. I continue searching for ways to effectively meet the needs of ALL students in the classroom.

After attending every seminar, workshop and professional development opportunity available to me, I discovered that no matter how great it sounded, it was difficult tailoring this new math curriculum to fit the needs of the students in my classroom. When the seminar was over, there was little or no support available to assist with implementation difficulties. Purchasing a small library of books and resources is helpful, but it is dreadfully slow going on your own. Student diversity has been my biggest challenge. Meeting the needs of every student, at times, seems like an impossible task. How do you teach 'factors and multiples' to students who do not understand multiplication? How do students that cannot divide whole numbers learn to divide fractions or decimals? How do you make math centers that are purposeful to both ends of the achievement spectrum? How do centers work into a timetable? Do you group students homogeneously, heterogeneously, or combinations of both? I began asking colleagues what they were finding and discovered that I was not alone. Teachers were experiencing many of the same issues within their classrooms. We face figuring it out problems in the isolation of our classrooms or risk feeling incompetent as we reveal to colleagues our pedagogical difficulties. Finding the time to work with colleagues, visit other classrooms, share problems, search for solutions, and discuss new innovative teaching practices is as obstacle that stands in the way of valuable collaboration. Working with an administration team that supports and encourages collaborative environments is critical to sustaining large school wide instructional initiatives.

Personal experience teaching mathematics has clearly indicated to me the importance of working together and supporting colleagues in reforming teaching practices. Despite a reasonably strong mathematical knowledge base, I continue to face challenges implementing instructional strategies that reflect the reform ideals.

Teaching practices today must continually change, evolve and improve, in an effort to prepare students for the changing world around them. Reviewing, reflecting, realigning and changing teaching practices is required to effectively meet the needs of our students and increase student achievement in mathematics. Teachers have been identified in research, as a key component in affecting changes within the classroom, For significant and sustained change to happen, there are several factors to consider. Teachers need to clearly understand and buy-in to the purpose of the changes they are expected to make. They need to have confidence in their content knowledge to enable effective engagement in pedagogical practices that reflect reform initiatives. Professional learning opportunities must be available for teachers to collaborate, learn and discover. Successful change is unlikely if teachers are left in isolation.

The purpose of this project is to explore and identify factors and influences that promote positive change to instructional practices in the mathematics classroom. A shared school goal focused on student engagement and increased mathematic achievement will drive the instructional change forward. Through professional development, shared leadership and collaboration with staff, parents and students, teachers will be empowered to make informed decisions on the implementation of best practices in their classrooms.

This paper will review the literature and data collected through extensive research on the history of mathematical curriculum and pedagogy. Examination of previous reform initiatives, the failures and successes, will be used to identify the key components that are necessary to

ensure that sustainable instructional change is made to improve schools and ultimately increase student engagement and achievement. The increasingly diverse classrooms create additional challenges for teachers today as they strive to meet the needs of each individual student. The broad spectrum of ability in each classroom is unique; therefore require instructional practices that remain flexible, yet purposeful. Chapter 3 provides a plan, based on the research, to develop and initiate change within an instructional leadership framework.

Chapter 2

Mathematics has been the subject of debate throughout the past century as it continues to find its way through decades of reform (Kilpatrick, 2012; Klein, 2003; Reys, 2001; Schoenfeld, 2004). Concern about our students' math education and achievement is nothing new (Vigdor, 2013). Issues that were problematic in the early 20th century continue to find their way into current debate and discussion, as the role of mathematics in the 21st century classroom is investigated and reevaluated (Klein, 2003). Our world is changing and in contemporary times, "schools are charged with the responsibility of equipping students with new work competencies and preparing them for a new globalized economy" (Cheng-Yong Tan, 2012, p. 184). As in the past, science and math relentlessly drives the advancement of a technological society within a large, global arena. With concern to keep our society in the forefront, pressure is placed on the education system to adopt and develop a mathematics curriculum that will provide students with the skills and attitudes that will prepare them to meet the needs of a sophisticated, scientific workforce (Fey & Graeber, 2003). In an effort to develop a mathematics curriculum that would serve all students across the US, the NCTM (National Council of Teachers of Mathematics) created the *1989 Curriculum and Evaluation Standards for School Mathematics*, a document grounded in the assumption that learning mathematics was an active process rather than one of memorization and practice (Schoenfeld, 2004), urging more student centered, discovery learning trends, similar to those of the 1920s (Klein, 2003). This reform called for new teaching practices (Schoenfeld, 2004). Teachers were encouraged to scrutinize their practices and adjust their beliefs and understanding to align with current trends and ideas. This arduous series of events is complex, multifaceted and disrupted by debate, disagreement and a tension that exists between what is taught and how it is taught (Ball, 2000; Reys, 2001). "In no country did school

mathematics return to where it had been before the new math movement began: The pendulum is not a suitable metaphor for curriculum change" (Kilpatrick, 2012, p. 569). The mathematical ideas and learning that came out of the 1970s "provided the context for the creation of the Curriculum and Evaluation Standards for School Mathematics in particular and reform in general" (Schoenfeld, 2004, p. 254). Alberta Education, like other jurisdictions in Canada and the United States are currently working to increase student achievement in mathematics by promoting teacher understanding and encouraging reform to teaching practices that no longer meet the needs of today's students. When evaluating the educational needs of the 21st century learner, in a world that is significantly different to the world a century ago, it is apparent that change to the educational system and teaching practices is required.

History of the Mathematics Curriculum

The mathematics curriculum has a long history of reform and debate (Schoenfeld, 2004). Reviewing the past, gives insight to the barriers that have been encountered and identify areas that may impede changes today. Concerns with mathematics education have been echoed several times throughout the twentieth century, a century that has seen constant change in mathematic trends (Schoenfeld, 2004). At the turn of the twentieth century, elementary education was instruction in the very basics, focused on meeting the needs of the masses, " while high school and beyond were reserved for the elite" (Schoenfeld, 2004, p. 254). Throughout the next two decades, mathematics education in North America was influenced by the progressive ideas of William Heard Kilpatrick (Klein, 2003). Kilpatrick to, as stated by Klein (2003), believed that subjects should be taught based on their practical value and stated in an address at the University of Florida that "[w]e have in the past taught algebra and geometry to too many, not too few" (Klein, 2003, p. 41). Kilpatrick was in favor of limiting education to utilitarian

skills. This would limit academic content and helped to "justify the slow pace of student centered, discovery learning, the centerpiece of progressivism" (Klein, 2003, p. 41). This led to the fragmentation of arithmetic (Klein, 2003), and debate over curricular content ensued. In 1920, the National Council of Teachers of Mathematics (NCTM) was founded. According to Klein (2003),

> [t]he first NCTM president, C.M. Austin, made it clear that the organization would "keep the values and interests of mathematics before the educational world" and he urged that "curriculum studies and reforms and adjustments come from the teachers of mathematics rather than from the educational reformers." The NCTM was created in part to counter the progressivist educational agenda for mathematics. . . (p. 40)

Klein (2003) states that major themes of progressivism were predominant in the 1930's. "The school curriculum would be determined by the needs and interests of children, as determined by professional educators, and not by academic subjects" (Klein, 2003, p. 41).

> In the 1940's it became something of a public scandal that army recruits knew so little math that the army itself had to provide training in the arithmetic needed for basic bookkeeping and gunnery. Admiral Nimitz complained of mathematical deficiencies of would-be officer candidates and navy volunteers. The basic skills of these military personnel should have been learned in the public schools but were not (Klein, 2003, p. 41).

Despite, the scandal it caused, there was no significant change in the actual curriculum as a result of the complaint (Schoenfeld, 2004). However, the "appearance of radar, cryptography, navigation, atomic energy, and other technological wonderments . . . underscored the importance

of mathematics" (Klein, 2003, p. 6) and by the 1950's change to the mathematic curriculum was attempted in a variety of ways (Kilpatrick 2012). "These efforts arose from various sources and took many forms, but they tended to have in common a desire to bring school mathematics closer to the academic mathematics of the twentieth century" (Kilpatrick, 2012, p. 563). In October 1957, the Soviet Union successfully launched the first Sputnik and the 'space race' was underway. This event elevated the efforts to reform mathematics in North America, Europe and other countries around the globe (Kilpatrick, 2012). Students would need to achieve mastery in higher level science and math. The pragmatic math of the past was no longer sufficient (Vigdor, 2013). Calculus courses were introduced at the high school level as part of the 'new math' movement (Klein, 2003). According to Klein (2003), "some of the New Math curricula were excessively formal, with little attention to basic skills or to applications of mathematics" (p. 8). "There were instances in which abstractness for its own sake was overemphasized to the point of absurdity" (Klein, 2003, p. 8). Teachers were not "well equipped to deal with the demanding content of the New Math Curricula" (Klein, 2003, p. 8), parents were confused and public criticism increased (Klein, 2003). The math curriculum of the 70's resembled that of pre-sputnik years (Schoenfeld, 2004). By the late 1970's new math was dead - and classrooms went "back to basics" (Klein, 2003). "Although the new math is often deemed a failed endeavor, it changed not only school mathematics but also the way people and countries viewed school mathematics" (Kilpatrick, 2012, p. 563). Davidson and Mitchell (2008) describe math reform in the twentieth century as one failure followed by another. The NCTM (1989) *Standards* offered "a penumbra of vagueness so that powerful groups or individuals who would otherwise disagree can fit under the umbrella" (p. 413), but was radical enough to challenge "many of the assumptions underlying the traditional curriculum" (Schoenfeld, 2004). These '*standards*' were received with

considerable scrutiny from both curriculum reformists and traditionalists (Schoenfeld 1994; 2004). The debate and disagreement between these two groups, the math wars, were portrayed by the journalists of the 1990s "as an extended disagreement between those who wanted basic skills versus those who favored conceptual understanding of mathematics" (Klein, 2003 p. 21). The math wars have left many believing that the math curriculum must be one or the other, traditional or reform (Schoenfeld, 2004). According to Schoenfeld, somewhere between the extremes "there is a rational middle ground, and many teachers seek it" (Schoenfeld, 2004, p. 283). A middle ground that would represent some compromise from the extremists, in order to provide a curriculum that would serve the needs of students (Schoenfeld, 2004). "An exclusive focus on basics leaves students without the understanding that enable them to use mathematics effectively. A focus on "process" without attention to skills deprives students of the tools they need for fluid, competent performance (Schoenfeld, 2004, p. 281). According to Schoenfeld (2004), the most significant reform document since the 1989 standards is the successor NCTM (2000) Principles and Standards for School Mathematics.

Teaching Practices: A Pedagogy Debate

Curriculum reform presents an immense challenge to classroom instruction (Spillane & Zeuli, 1999). The mathematics reform initiated by the NCTM (1989) *Standards* challenged traditional teaching practices (Schoenfeld, 2004). Teachers were called upon to assume different roles in the classroom in order to achieve complex learning outcomes (Pape & Smith, 2002) and history shows that with reform comes conflict (Marshall, 2003) and challenge. When government funds were provided for the creation of new textbooks, it was seen as a solution to implementing the *new math* reform (Sherin & Drake, 2009). These curricular materials would be made available to teachers and would accurately align mathematics instruction to the curriculum.

Unfortunately, "teachers were noticeably absent from [the design] process" (Sherin & Drake, 2009, p. 469) and the implementation. Including teachers in the "enactment of the materials . . . was presumed to be a trivial step in the process" (Sherin & Drake, 2009, p. 469). Failure to consider the teachers as a "critical link in the reform process" (Sherin & Drake, 2009, p. 469) created considerable difficulty for the *new math* reform agenda (Kilpatrick, 1997). The *new math* curriculum failed in the 1970s because it was "a top-down reform, initiated by the mathematical community, without buy-in from teachers or the public" (Davison & Mitchell, 2008, p. 147). Reformists neglected to include teachers, parents or students, underestimating their importance in the reform efforts (Kilpatrick, 1997). By the end of the *new math* era, it was realized that reform to the mathematics curriculum would take much more than providing a new curriculum and instructional resources (Kilpatrick, 2012). "At the crux of any curriculum change is the teacher" (Kilpatrick, 2012, p. 569). Teacher buy-in and beliefs are key components to a system wide change in the way that mathematics is to be taught (Kilpatrick 1997; 2000; Sherin & Drake, 2009). Teachers need to understand the curricular changes and agree with them (Kilpatrick, 2012) before they can adopt any change and align their practices accordingly (Klein, 2003; Schoenfeld, 2004). Generally speaking, Klein (2003) explains the nature of these educational wars of the past century, as a "protracted struggle between content and pedagogy" (p. 3). "There should no more be conflict between content and pedagogy than between one's right foot and left foot. They should work in tandem toward the same end, and avoid tripping each other" (Klein 2003, p. 2).

Curriculum and Pedagogy

Research has shown that different teachers use the same curriculum materials in a variety of different ways (Land & Drake, 2014; Remillard, 1999; Sherin & Drake 2009). No curriculum is "teacher-proof" (Drake & Sherin, 2006; 2009; Remillard, 1999). Teaching and learning is a complex relationship (Loughran, 2013). "There is no one way to teach a subject and no one way that all students learn that subject" (Loughran, 2013, p. 120). As a result of the complexities, teaching can be problematic (Ball, 1993; Loughran, 2013). When working with curriculum, different teachers make different choices on how to help students achieve conceptual understanding (Drake & Sherin, 2006; Remillard 2005). Teachers' perceptions of the students needs will also affect the way that the curriculum materials are used in the classroom. Shulman (1986) used his idea of PCK (Pedagogical Content Knowledge) to show the complex relationship between teaching, learning and curriculum. Shulman (1986) described it as including "the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a work, the ways of representing and formulating the subject that makes it comprehensible for others" (p. 9). Schulman moved the idea of teaching "beyond simplistic views of 'teaching as telling' and 'learning as listening" (Loughran 2013, p. 123). "PCK is concerned with how subject matter knowledge can be transformed through pedagogical situations so that the particular subject matter under consideration is better understood by students" (Loughran, 2013, p. 124). Schulman's ideas suggest that it is "not only knowledge of content but also knowledge of how to teach content that influences teachers' effectiveness" (Hill, Rowan, & Ball, 2005, p. 377). "Research supports the importance of teachers development of pedagogical content knowledge, built upon a deep understanding of how students think and develop mathematically" (Small, 2013, p. 2). Mathematical reform "provided new content knowledge but did not address the

pedagogical problems of teaching that new content" (Kilpatrick, 1997, p. 5). "If education is to change, it has to happen in the classroom" (Kilpatrick, 1997, p. 3) It can be "risky and troublesome . . . for teachers to make substantial changes to their practice" Kilpatrick, 1997, p. 5). Teacher buy-in is closely associated to their beliefs and this becomes an important factor in curricular reform (Kilpatrick, 2012; Schoenfeld, 2004). "If teachers feel uncomfortable with a curriculum they have not been prepared to implement, they will either shy away or bastardize it" (Schoenfeld, 2004, p. 257). There is concern that the mathematics curriculum is not presented in the classroom in the way in which it was designed. What teachers believe about subject matter and how they interpret reform objectives, reflects in their daily teaching practices. Teachers need a motivation to change. Teachers do not change their practices without "strong incentives and substantial support" (Kilpatrick, 1997, p. 5). Mathematics reform continues to progress unevenly among schools and classrooms. While some teachers have undertaken substantial changes, others have managed only modest revisions. Reform continues to promote considerable change in mathematics curriculum and pedagogy, and "because textbooks and curriculum materials have figured significantly in mathematics teaching and in reform efforts, the field of mathematics offers a fruitful opportunity to examine teacher - curriculum relationships" (Remillard, 2005, p. 214). Mathematical knowledge is obviously important for teachers to have, but equally important is understanding students and learning. Ball (1993) points out concern with "helping teachers transcend their own school experiences with mathematics in order to create new practices of mathematical pedagogy" (p. 395).

Classrooms Today

"Mathematics is one way of trying to understand, interpret and describe our world" (Alberta Education, 2014, p. 7) As we have moved into the highly technical, information age,

"it is clear that students will need more mathematics than their parents did yesterday, and they will need to be taught in a far better way" (Marshall 2003, p. 194). Mathematical instruction must provide more to students than just content mastery (Schoenfeld, 2004). Knowledge can be thought of as "something that we either have or don't have"(Van de Wall & Lovin, 2006, p. 2) whereas, "[u]nderstanding is never an all-or nothing proposition" (Van de Wall & Lovin, 2006, p. 2). Students must have both knowledge and understanding that will enable them to engage in tasks, contribute in mathematical discussions and articulate their reasoning (Alberta Education, 2014). The mark of powerful learning is the ability to solve problems in new contexts or to solve problems that differ from the ones one has been trained to solve" (Schoenfeld, 2004, p. 262). Historically, math teachers have relied on textbooks (Remillard, 2005). However, simply correcting yesterdays work, copying teachers examples, practicing textbook questions as a class and moving on to the next lessons is not adequate . Teachers must "de-emphasize answers and correctness as the only worthy goals" (Myers, 2007, p. 696) in mathematical instruction. Mathematics is much more that rules, procedure, memorization, and right answers (Cohen & Ball, 1990). Teachers that still "view math as a body of facts and memorized procedures, must look at constructing mathematical knowledge through exploration and problem solving" (Pape & Smith, 2002, p. 93). Students need opportunities to confront mathematical problems and be able to articulate the reasoning behind their own ideas (Cohen & Ball, 1990). Reform goals have "been set forth that include an emphasis on conceptual understanding, communicating reasoning and mathematical understanding, and learning through problem solving and inquiry" (Pape & Smith, 2002, p. 93). "Instruction should vary and include: appropriate project work; group and individual assignments; discussion between teacher and students and among students; practice on mathematical methods; exposition by the teacher" (NCTM, 1989, p. 10). The NCTM is one of

the most influential organizations in mathematics education in North America, in which many Canadian educators take an active role. As a result, this understanding of mathematical instruction has been replicated throughout curriculum in North America. "Many of the central documents produced by this organization have had a profound effect on the mathematics directions taken in Canada and the United States" (Small, 2013, p. 2). These contemporary visions today are not new. "They are rooted in the visions of our educational forebears - among them thinkers such as Bruner, Dewey, and Schwab" (Ball, 1993, p. 374). Many of the historical issues related to mathematical reform persist today. Taking the vision of current reform and making it reality within classrooms continues to be complex, problematic, and not without dilemmas faced by the classroom teachers (Ball, 1993). In addition to curriculum and pedagogical relationship in mathematical instruction, the context in which the teaching and learning is taking place must be considered.

Diversity

In an effort to provide adequate math instruction to all students, teachers face, not only curriculum reform, but addressing the needs of students within a highly diverse inclusive classroom environments. Students today are socially promoted to the next grade, not held back as they were in the past, based on academic achievement. Each classroom has a broad spectrum of ability, in addition to cultural and socioeconomic factors (Ball, 1993). Teachers are "charged with helping all students learn mathematics, in the same room at the same time" (Ball, 1993, p. 377). Today's inclusive education has teachers working in a modern day "one room schoolhouse" (Anderson, 2007, p.). Providing mathematic instruction for each student requires teachers to identify where each student is in terms of their individual understanding and move them forward. Alberta Education has defined an inclusive education system as "one that takes

responsibility for all students, focuses on their strengths, and emphasizes what they can do rather than focusing on their limitation" (Inspiring Action on Education, 2010, p. 12). The complexities begin when understanding the uniqueness of each individual. Teachers teach in different ways, and students learn in different ways. "If teachers overlook individual differences, they become blind to individual needs" (Ross, 2001, p. 241). "Rather than wish differences among students away, a rational policy for the 21st century will respond to those , tailoring lessons to children's needs" (Vigdor, 2014, p. 9)**.** The vision of Alberta Education includes personalized learning for all students. This means that "students progress at a pace that suits their needs and enhances their success" (Inspiring Action on Education, 2010, p. 14). The dilemma for teachers becomes finding ways to cover the prescribed content, in 180-190 days, meet the individual needs of each student, and do so using practices that foster the current ideologies of student learning (Ball, 1993). Typically, teachers are left to work through problems in isolation. with little opportunity to share information, ask questions or seek alternative solutions to problems (Ball, 1993). "If mathematics teachers are to meet the needs of the increasingly diverse student populations in their classrooms, they need time to plan, study, reflect, develop curriculum, and confer with colleagues" (Martin & Speer, 2009, p. 403).

What Teachers Need To Support Change

"Designing infrastructures to support instruction remains a challenge in educational reform" (Hopkins, Spillane, Jakopovic, & Heaton, 2013 p 200). Historically, math instruction has been associated with teachers utilizing textbooks and related support material (Remillard, 2005). In the US, millions of dollars have been spent developing resources to support teachers teaching mathematics, but very little is known in regards to how they are actually used (Land & Drake, 2014). Evidence suggests that teachers in the US lack essential knowledge for teaching

mathematics (Ball, 1993; Hill et al., 2005). Unlike high school teachers, teacher at the K-8 level have not had "the luxury of specialist training in mathematics, yet they are expected to teach an increasingly sophisticated curriculum to an increasingly diverse student population to a climate where there are heightened public expectations" (Small, 2013, preface). When the 1989 NCTM Standards called for new teaching practices, they were speaking to many teachers who had experienced mathematics in traditional ways and were now being asked to teach in new ways (Myers, 2007; Schoenfeld, 2004; Sherin & Drake, 2009). Teachers trained with rote methods were not given an opportunity to "appreciated the underlying richness" (Myers, 2007, p 694), of mathematics. Introducing new mathematical topics and new instructional approaches would require teachers to do some learning (Sherin & Drake, 2009). This means that teachers will need to know the math well (Hopkins et al., 2013) and understand the practices that are needed to implement the math curriculum in the way it is designed. Moreover, the creativity entailed in designing instruction in ways that are attentive to difference requires substantial proficiency with the material (Ball, 2000). "Teaching is a complex endeavor, and expert teachers should work collaboratively with other teachers and administrators to address issues of professional [development] and school improvement" (Martin & Speer, 2009, p. 403). Reform calls for knowledge and flexibility on the part of the teacher. Teacher Education must be explored to ensure that the new teachers are prepared (Meyers, 2007) for the realities and the complexities of teaching mathematics. Providing them with the information, knowledge and confidence to ask questions of themselves and encourage their students to do likewise, (Myers, 2007) especially in mathematics. Mathematics is about rules and procedures, however, they are interrelated, "and beneath them there is a web that connects them conceptually" (Myers, 2007, p. 694). Connecting teachers today, and teachers of the future, to this underlying mathematical structure

will enable them to help their students connect in a similar way (Myers, 2007). School communities need to develop a culture that provides opportunity for teachers to learn and collaborate with each other. Teachers must be willing to question their practices and discuss collaboratively the problems they encounter teaching mathematics in order to seek effective solutions (Ball, 1993). They must be willing to let "one another and others behind the proverbial classroom door, to explore one another's practices, to raise hard questions, and to help one another grow" (Ball, 1993, p. 369).

Moving Forward

Sustainable instructional change that results in school improvement is a process that requires strong leadership (Beauchamp & Parsons, 2012), that includes an instructional leadership framework (Cheng-Yong Tan, 2012; Harris, 2007; Lambert, 2002), a shared vision, collaboration (Ball, 1993) and effective communication among all stakeholders (Cheng-Yong Tan, 2012; Lambert, 2002). School leaders need to move forward by empowering teachers as professionals (Cheng-Yong Tan, 2012) and leveraging "on the collective energies of all teachers" (Cheng-Yong Tan, 2012, p. 184). The focus must be on teacher growth and learning rather than simply their compliance to new directives (Hoy & Hoy, 2006) as a way to implement effective change within the classroom. Teachers need to be active in the acquisition of information and skills related to the task of teaching their students. They need to be willing to discuss pedagogical difficulty openly and honestly, without feeling that they are "admitting to professional incompetence" (Ball, 1993, p. 395). The passive model of knowledge application, where teachers learn about new pedagogies and then apply them in their classrooms, is no longer sufficient (Cheng-Yong Tan, 2012). It "deprives teachers of the opportunity to exercise their professional autonomy in experimenting to discover the most effective pedagogies in

collaboration with their colleagues" (Cheng-Yong Tan, 2012, p. 185). Providing opportunity for collaboration among teachers is beneficial in moving the reform effort forward (Bruce & Ross, 2008). In an effort to improve student learning and performance, Alberta Education developed the AISI (Alberta Initiative For School Improvement) Project. School authorities were provided with additional funding for specific initiatives to improve student learning. In Dickson, Davis, Lorway, and Wood's (2005), AISI Mathematics and Numeracy Research Review, they found that "successful AISI projects supported:

- regularly scheduled, job-embedded time for teacher collaboration
- a common culture of action research and shared inquiry
- significant leadership support at school and district levels
- empowerment of participants and ongoing professional growth of teachers
- a clear and shared focus on the goal of student learning" (p. 1).

"The days of the principal as the lone instructional leader are over" (Lambert, 2002, p. 37). Instructional leadership must be shared and distributed throughout the school community (Cheng-Yong Tan, 2012; Harris, 2007; Lambert, 2002). "Leadership is the professional work of everyone in the school" (Lambert, 2002, p. 37). A principal alone does not have the accumulated expertise that exists within the professional staff. They become partners who empower teachers by including them in planning and decision making (Beauchamp & Parsons, 2012). Working within a framework of shared or distributed leadership, exposes the talents of the teachers (Lambert, 2002) and taps into a valuable resource of knowledge, skills and experience. "Communities of practice and shared networks of learning professionals are said to thrive" (Cheng-Yong Tan, 2012, p. 184) when leadership is distributed among the teachers. Strong school leaders build strong relationships based on "trust, honesty, communication, openness,

transparency, responsibility, and accountability" (Beauchamp & Parsons, 2012, p. 43). They invest the time to know the people they work with (Beauchamp & Parsons, 2012). They "model the way, inspire a shared vision, challenge the process, enable others to act, and encourage the heart" (Kouzes & Posner, 2007, p. 64).

Lambert's (2002) research on High Leadership Capacity Schools, emphasized the need for a shared vision. The principal's role is to formulate school goals that focus on the academic progress of students (Hallinger & Heck, 2010). Beauchamp and Parsons (2012) point out that Lambert's research (2002) emphasizes "the need for a shared vision, using data to drive decisions and developing capacity among all members of the school community" (p. 43), when describing highly effective schools. The reason(s) for the goals need to be clearly articulated (Beauchamp & Parsons, 2012) to all stakeholders, in an effort to obtain 'buy-in'. School leaders must be patient and willing to allow teachers to gain the vision (Beauchamp & Parsons, 2012) and build consensus related to the development of relevant short term goals (Leithwood, 2005). With a clearly stated, shared vision for the school, stakeholders that include: staff, teachers, students and parents, can work collaboratively to optimize learning (Hallinger & Heck, 2010).

Effective leadership is important in the implementation of "collaboration as a form of professional learning" (Johnson Abbott & McKnight, 2010, p. 22). "Collaborative learning teams have emerged as an effective tool for teachers to steadily and continuously improve their instruction" (Johnson Abbott & McKnight, 2010, p. 20), when they foster a culture that is focused on learning (Cheng-Yong Tan, 2012). When principals provide teachers the opportunity to come together around instructional goals, on a regular basis, teachers begin to take more initiative in examining instructional practices and strategies (Johnson Abbott & McKnight, 2010).

Building a collaborative school community requires school leaders to encourage teachers to participate in decision making (Leithwood, 2005). In addition to teachers "[s]uch collaboration is building a sense of collective responsibility among students and parents for the accomplishments of all students" (Lambert, 2002, p, 41)

Communication is important "because it create[s] a shared language and vision" (Beauchamp & Parsons, 2012, p, 46) to all stakeholders. Effective leaders must be skilled communicators that clearly articulate their visions and goals and are open and willing to listen carefully and flexible to consider the ideas of others (Beauchamp & Parsons, 2012; Leithwood, 2005). Schools that initiate successful change understand that honest, open, and regular communication allows stakeholders to reaffirm goals, modify plans, evaluate progress, discuss challenges, and celebrate successes.

Effective leadership is "specifically linked to successful student learning" (Beauchamp & Parsons, 2012, p. 41). They suggest that good school leaders must "be big enough to become small" (Beauchamp & Parsons, 2012, p. 47) and step aside to allow teachers to adopt the vision, work with other teachers, assume leadership roles, and solve problems (Beauchamp & Parsons, 2012). In the AISI Mathematics and Numeracy Projects Research Review, "[k]ey findings. . . are:

- A significant element of successful projects was the development of teacher capacity.
- Successful projects sustained a clear and direct focus on improving student achievement
- successful projects were developed and implemented in a climate of collaboration, encouragement and support.
- Effective project management played an essential part in achieving desired outcomes" (Dickson et al, 2005, p. 1).

"It is an ambitious effort to shift mathematics teaching from mechanical drill and memorization toward mathematical reasoning and understanding" (Cohen & Ball, 1990, p. 234). Opposing views on the content of the math curriculum have caused a century of battle and debate among those in the education system. The education reform of today has little to distinguish it from earlier reforms at the turn of the 20th century and the reform of the New Math era of the 60sand 70's (Klein, 2003). These reforms reflected progressive ideas that viewed mathematics as contributing to mental discipline (Klein, 2003). Students would be learning mathematics by discovery and their learning would be more student-centered. The opposing views believed that "mathematics education should be for purely utilitarian purposes" (Klein, 2003). Algebra and geometry would be discontinued "except as an intellectual luxury" Klein, 2003, p. 3).

In the Framework for Student Learning, Alberta Education (2011) has identified literacy and numeracy as the foundational skills required to successful learning and living. "Governments, business leaders, researchers and communities in Alberta, Canada, and around the world, investigating the requirements of 21st century learners, have identified the need for competencies to be more central in the education of young people if they are to be active participants in an increasingly knowledge-based and globalized society" (Alberta Education, 2010, p. 9). At the center of a competencies-based, student-focused curriculum are the literacy and numeracy skills (Alberta Education, 2010).

The NCTM (1989) *Standards, developed* around constructivist learning principles, has been identified as an influential framework to the development of current mathematics curriculum in Canada and the United States (Small, 2013). "Constructivist learning principles such as learning by doing, regulating one's own learning, building individual meaning in a situation or experience, and learning with and from others are clearly more easily achieved if the

practice setting is organized, develop and enacted in ways that support those principles" (Loughran, 2013). The NCTM (2000) *Principles and Standards for School Mathematics,* "has been a guiding force for the reform in school mathematics" (VandeWalle & Lovin, 2006, p. xii). Some believe the spirit of this reform could be easily translated into practice in the classrooms by way of textbook, it is clear that the simplistic view has its flaws. Past experience has demonstrated that successful implementation of mathematics reform standards requires a curriculum that is accessible to all stakeholders (Schoenfeld, 2004). Parents, students and teachers all have key roles in mathematics reform and its success within the classroom. Alberta Education (2010) points out that successful change or reform must be done collaboratively by all - "from teachers and principals, to educational organizations and associations, to students and parents and all committed Albertans" (Alberta Education, 2010, p. 3).

"How can teachers teach a mathematics that they never learned, in ways that they never experienced" (Cohen & Ball, 1990, p. 238)? "Teachers are, in one sense, the problem that policy seeks to correct. On the other hand, teachers are the most important agents for improving things" (Cohen & Ball, 1990, p. 238). The world continues to change and our education system must keep up (Alberta Education, 2010).

Chapter3

Building a Community To Support Student Achievement in Mathematics

This project is a plan to initiate the development of a school community, which includes all stakeholders, focused on increasing student engagement and achievement in mathematics. Alberta Education has identified literacy and numeracy as being "primary importance to all learning" (Alberta Education, 2010, p.9). Mathematics has not changed; however, the way it is being taught is significantly different to the way that many teachers and parents were taught in school. In addition, most elementary school teachers have generalist degree which usually includes only two required mathematics courses. As a result, changing instructional practices from traditional, teacher-centered lessons to student discovery learning in elementary mathematics, can become problematic for some teachers. Teachers have limited personal experience with practices reflected in the current mathematics curricular reform. Curriculum is developed by governments working with experts in subject areas and educators based on the perceived skills, knowledge and attitudes that students of today will need as they grow into the adults of tomorrow. The curriculum is passed on to teachers, who in turn must consider the uniqueness of each student, identify their strengths, their weakness, their prior knowledge, their understanding of the subject, and move each student forward towards the curricular objectives and grade level goals. Despite the class size and the diversity of the students, teachers have less that 200 days to reach the curricular objectives.

School boards and districts around the world are constantly reflecting on the work schools are doing and seek out ways to promote and support student and teacher growth. Schools are about teaching and learning. The learning in schools, however, is not limited to the students. Teachers are committed life-long learners that constantly reflect, modify and realign

their lessons to meet the unique needs of each student within each classroom. Teachers often work in the isolation of their classroom bound by time restraints and the increasing demands of diverse communities. Collaborative opportunities allow teachers to contribute and share innovative and creative ideas based on their expertise and experience. Teachers can provide valuable feedback to each other, discuss problems, search for solutions, make decisions and reflect on the learning environment they are responsible for creating. Building a professional community that includes all stakeholders moving towards a common goal with the vision of maximizing the potential of each student can become a powerful force that propels schools forward. According to Alberta Education (2010), "[a]ll of us - from teachers and principals, to educational organizations and associations, to students and parents and all committed Albertans - must pull together to accomplish change" (p. 3).

The primary goal of the following plan is to effectively meet the mathematical needs of students and increase achievement by providing students with a strong foundation for numeracy that more complex skills can be built upon. Through a collaborative effort, all stakeholders working towards a common goal, become substantially more powerful than one teacher working in isolation. Changes become sustainable when administrators, teachers and parents clearly understand the need for change and work together to seek solutions. In working towards this goal, the expectation is that teaching practices will change to align towards a more student directed learning environment that effectively meets the needs of all students within a classroom today. Teachers will contribute to the development of an eclectic program of innovative ideas and teaching practices that can be shared with other teachers. Parents will be given an opportunity to learn and develop an understanding of the current vision of numeracy. This will alleviate fear, build confidence and equip parents with the information required to support their

children at home. Students will develop stronger foundational skills in mathematics that will facilitate new learning and increase their achievement. A strong school community developed through the collaboration of all stakeholders, creates a culture that places students, their needs and achievement at the center.

The following plan creates a framework that outlines key steps to consider in an effort to successfully create sustainable change to teaching practices in mathematics. With student needs and achievement anchored in shared vision, goal(s) can be developed for improving schools and classrooms. Strong leadership will work towards the development of a culture to support teachers by facilitating their learning and empower them to exercise their professional autonomy in discovering the most effective instructional practices. According to Drake and Sherin (2006), "to effect change, curricula need to not only support student learning, but also directly address teacher's learning and teaching needs" (p. 154). The development of a collaborative community within this plan will include, leadership, teachers, school staff, parents, and students. Opportunity will be provided for all stakeholders to clearly understand the need for change and encourage them to become involved. This will generate the momentum required to initiate change. Change is difficult, requires a substantial amount of effort, and takes time. Developing a plan, that is shared and understood by all stakeholders, is important to maintain focus and momentum to move change initiatives forward.

Step 1: Formulate a Goal

Share the school vision and clearly outline a goal that can be communicated and understood by all stakeholders (Cheng-Yong Tan, 2012; Lambert, 2002) within the school community. School principals must clearly articulate the reasoning for the goal in an effort to have all stakeholders

understand the importance of the goal and be willing to work collaboratively to achieve it. Begin by reviewing current provincial initiatives.

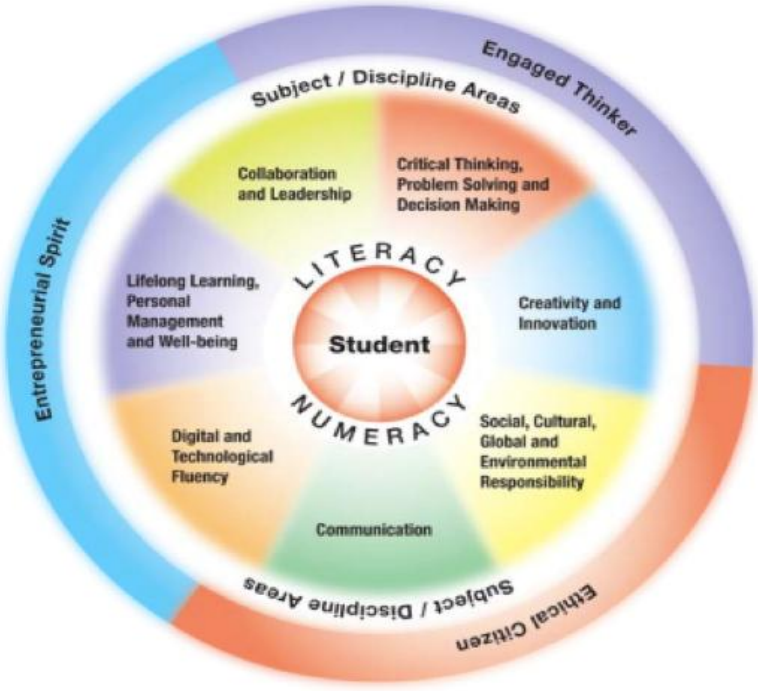

Figure 1. Framework for Student Learning. Alberta Education (2011, p.2) uses this graphic to illustrate the vision for competency based learning.

"The Framework for Student Learning outlines the relationships among literacy, numeracy, competencies and subject/discipline areas essential for students to become engaged thinkers and ethical citizens with an entrepreneurial spirit" (Alberta Education, 2011 p. 2). Literacy and numeracy skills, at the center of the framework, have been identified as foundational to student learning. Students, according to Alberta Education, are "at the centre of all decisions and discussions related to curriculum" (Alberta Education, 2011, p. 3). A goal related to student achievement in mathematics, would therefore be relevant to the current reform initiatives in Alberta schools. Alberta Education (2011) has also stated in the framework that numeracy skills "go beyond the basic skills . . . [of] solving arithmetic problems to acquiring, creating,

connecting and understanding information" (Alberta Education, 2011, p. 3). This information is important to share with staff and parents to ensure their understanding of the relationship between the school numeracy goal and shared vision of Alberta Education.

In alignment with Alberta Education's vision, school district has identified their goals similar to the following:

- Students have engaging and collaborative learning experiences that prepare them to be active, creative, knowledgeable participants in our global society
- Students have engaging and collaborative learning experiences that prepared them to be critical thinkers and problem solvers
- Students are global citizens who respect and value diversity
- All students have their individual needs met within inclusive learning environments

As a school within this jurisdiction, the numeracy goal stated as; *students at ABC Elementary School will have numeracy skills or are working towards attaining numeracy skill that are at or above grade level* (appendix A), would be applicable and align with current goals set out at the provincial and district level. Identifying a clear goal that aligns with jurisdictional goals, will allow for staff to develop an understanding of the purpose of the goal and provide teachers the opportunity to participate in developing and obtaining short term objectives focused on the long term goal. This initial step would facilitate the instructional leadership framework defined in chapter 2.

Step 2: Financial Considerations

School administrators must consider possible costs and expenditures associated with pursuing the determined goal. Budget for expenditures should include:

- Facilitating release time for teachers - This would include funding allocated for substitute teachers that would permit time for teachers to collaborate, visit classrooms, and attend applicable outside conference or workshop opportunities.
- Cost of hosting guest speakers that would attend and provide school based professional learning opportunities to staff.
- Acquisition of a Universal Screening Assessment characterized as a quick, low-cost, repeatable testing of age-appropriate skills for all students.
- Resources that would include:
    - professional resources to support teacher growth and understanding of student centered mathematics (example: Teaching Student-Centered Mathematics by John A. Van de Walle and LouAnn H. Lovin)
    - models or tools for learning (example: manipulatives, technology tools) for use in the classroom.

To provide a focus for an initial collaborative meeting, teachers can be tasked with creating a 'wish list' of school and classroom resources and materials that may be required.

Step 3: Acquiring a Universal Screening Assessment

There are several assessment tools available for elementary school mathematics. To clarify the purpose of different assessments, Connecticut State Department of Education (2012) explains the characteristics of universal screening assessments, diagnostic assessments, and progress monitoring assessments. Clearly understanding the purpose of the different types of assessment tools, ensures the acquisition of one that effectively meets the needs. The appropriate tool for the purposes of this plan is a universal screening assessment. The Connecticut State Department of

Education (2012) provides the following list of "characteristics . . . as identified in the professional literature:

- accessible to all students
- access critical skills and concepts
- brief (under 10 minutes), easy to administer and score
- given to all students
- quick turn-around time (1-3 days) of aggregated and disaggregated data to classroom teachers
- repeatable
- reliable (commercial assessments have undergone psychometric analyses to determine reliability. A "teacher-made" assessment cannot be referred to as reliable if it has not been analyzed by a psychometrician)
- valid (Commercial assessments have undergone psychometric analyses to determine validity. The inferences made from a "teacher-made" assessment cannot be referred to as valid, if it has not been analyzed by a psychometrician)" (p. 1).

The data collected would provide information that would identify students that were meeting expected curricular outcomes and those students that were not. This would assist teachers in focusing instruction that would meet individual needs. It would provide teachers with a tool to identify students' prior knowledge for the strands in the mathematics curriculum and to provide consistent and reliable data on all math strands at each grade. Teachers could utilize this information for grouping students homogeneously and heterogeneously. Cross-grade projects and activities could be developed to enhance student learning. The data would reinforce

a need to examine current practices related to mathematics and make changes to enhance student achievement. Completing school wide screening at regular determined intervals would be a method of measuring student achievement.

Step 4: Timetable Structure

Timetable structure in elementary school has traditionally been thirty minute periods assigned to each subject, with the exception of specific times designated for the use of the gymnasium, library, computer lab or those classes taught by a specialist (i.e. - second language, music, or drama). Each teacher, depending on the grade they were teaching, would fill each space of the timetable with a specific class, being mindful to the prescribed number of periods designated for each subject.

To facilitate and encourage multi-grade activities and flexible grouping options, the adoption of a school wide schedule that provided large chunks of time to focus on literacy and numeracy in the mornings would be implemented. The afternoon would focus on time outlined more specifically to the additional curricular needs of each class. Structured time periods would be necessary for gymnasium, computer lab, and library use, in addition to teacher 'prep' time and classes taught by specialist teachers. Taking into consideration project based learning activities, where several subject outcomes are assessed within one project, or any cross-curricular teaching that is done, subjects are not necessarily taught in isolation, nor do they follow the rigidity of regular scheduling. The timetable illustrated in *figure 2*, would continue to allow teachers to determine the structure of their day, yet make time available and flexible for teachers to work together with multi-grade or same grade activities and projects.

	Monday	Tuesday	Wednesday	Thursday	Friday
8:30 - 10:00	Literacy	Literacy	Literacy	Literacy	Literacy
10:00 - 10:15	Recess	Recess	Recess	Recess	Recess
10:15 - 11:45	Numeracy	Numeracy	Numeracy	Numeracy	Numeracy **collaboration*
11:45 - 12:30	Lunch	Lunch	Lunch	Lunch	Lunch
12:30 - 1:00					
1:00 - 1:30					
1:30 - 1:45	Recess	Recess	Recess	Recess	Recess
1:45 - 2:15					
2:15 - 2:45					

Figure 2. Proposed Timetable. This figure illustrates the basic timetable structure for each class.

Alberta Education (2010), envisions a competencies-based, student-focused curriculum for learning (*figure 1*), where numeracy and literacy remain "competencies of primary importance to all learning" (p. 9). Literacy and numeracy are key competencies to learning in all other subject areas and are not taught or assessed in isolation. Large chunks of time designated for literacy and numeracy could encompass other subject areas in multi-grade or same grade projects. It could facilitate grade group teachers sharing homogeneous groupings for small group instruction and opportunities for students to mentor other students. Teachers could independently, with grade group partners, or collaboratively as a school determine the best way to spend all, or a portion of the numeracy time. Perhaps teachers will determine that one particular day will be assigned to a multi-grade projects, two days each week to independent class instruction and activities, and two days of math centers and small group instruction across

different grades. The time is made available for teachers to continue in more traditionally scheduled classes or the flexibility to use the time to work collaboratively with other teachers to provide mathematics instruction to more than one class or perhaps more than one grade. The teachers can work together, investigate and examine innovative and creative ways to use the time. Providing teachers an opportunity to meet regularly is important. A thirty minute block before lunch would be put into the weekly schedule and designated as 'numeracy' collaboration time for teachers *(figure 2*). Students would be involved in activities arranged and organized by administration. These activities or assemblies could be multi grade group activities supervised by administration and educational assistants. Initially, teachers could be tasked to use this time to create math word lists for each grade. Teachers at each grade level could use the mathematics curriculum to determine important mathematics vocabulary that would be appropriate and could be used to build 'word walls' in the classrooms. Teachers could be asked to work together to create 'math journal' templates for different strands at each grade level in an effort to build resources that other teachers could access when meeting the needs of students above or below curricular expectations. Once initiated and the purpose of this time is understood, teachers could suggest different ways to utilize this time to meet goal objectives.

Step 5: Share the Vision, Goals and Objectives With Staff

"Highly effective principals build and communicate common goals, a common sense of purpose, and a clear vision" (Beauchamp & Parsons, 2012, p. 45).

The numeracy goal within the School Education Plan could be presented by a Slide Presentation at a staff meeting early in the school year. Figures 3 - 6, are examples of slides that could be used to share the goal, the outcome and an outline of the plan. Specific details, short-

term objectives, and planning would be the responsibility of the collaborative team that would be developed through an instructional leadership framework.

WORKING TOGETHER
TO
BUILD A MATHEMATICS COMMUNITY

Alberta Education Video - MATH: IT'S MINE
https://education.alberta.ca/teachers/program/math.aspx

Figure 3. Presentation to the Staff. Graphic and video link related to student-centered activity.

Following a link within the presentation would link to a short video selected from the math video collection created by Alberta Education, easily accessible on their website. This short video (1:27), Math: It's Mine, captures a classroom that reflects an environment that is student-centered. Students are engaged and working independently or in small groups solving math problems using different strategies, some including manipulatives. The second slide (*figure 4*) would state the numeracy goal, as part of the school education plan and preface the discussion prompted by the questions: How are we doing 'math' well? How could we do 'math' better? Teachers will break into small groups to discuss and share feedback to whole group.

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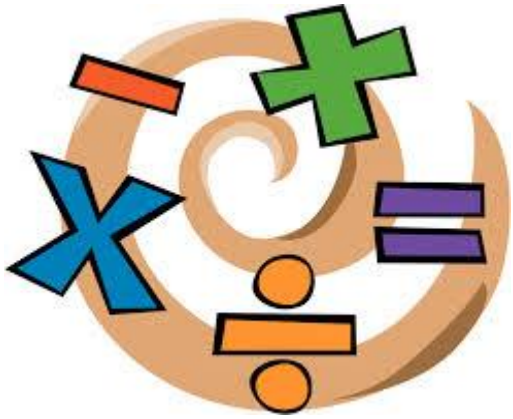

Our Goal:
"Students at our school will have numeracy skills or will be working towards achieving numeracy skills that meet or exceed curricular expectations"

Figure 4. Presentation to the Staff. Goal for school education plan introduced.

WORKING TOGETHER
TO
BUILD A MATHEMATICS COMMUNITY

WHY??

For the students * For their future * For their success

Figure 5. Presentation to the Staff. This graphic illustrates the idea of teachers collaborating and working together.

This slide would lead into the next question for discussion. Are we meeting the mathematical needs of each student in our classrooms? Are all students working at grade level in mathematics?

WORKING TOGETHER
TO
BUILD A MATHEMATICS COMMUNITY

- timetable change reflecting 'whole school' literacy and numeracy focus each morning
- weekly scheduled collaboration time for teachers
- dedicated time during each staff meeting for numeracy
- leadership roles assumed by teachers
- professional learning focused largely on numeracy
- teachers work collaboratively to increase student achievement in mathematics
- parents work collaboratively with teachers to increase student achievement in mathematics

EXPECTED OUTCOME: **Increased student achievement in mathematics!!**

Figure 6. Slide Presentation to Staff. The outline provides important steps required to the achievement of identified goal.

Review the components identified in the slide (*figure 6*), that constitute key elements to the overall vision. Explain how this will initialize the development of a collaborative learning community that will move forward to reach a shared outcome. Encourage input, ideas and questions from the teachers. It is important for effective leaders to listen carefully, (Leithwood, 2005) remain positive, open-minded and encouraging. In their study of highly effective elementary schools in Alberta, Beauchamp & Parsons (2012), identified negativity to be

detrimental to effective leadership. They found that negativity "eroded momentum and spirit" (Beauchamp & Parsons, 2012, p. 48), and destroyed teachers' enthusiasm (Beauchamp & Parsons, 2012). Obtaining teacher buy-in is critical to successfully developing leadership through the teachers and ultimately pivotal to the attainment of the outlined goal. Teacher leader roles are not simply inserted into schools, but developed with significant principal support (Mangin, 2007). Working as a collaborative team increases the skills and knowledge resources by tapping into teacher experience and expertise.

the mathematics universal screening assessment can be introduced to staff as a vehicle for making decisions, monitoring student progress and measuring growth. To encourage and develop an environment that embraces risk-taking and change, the assessment tool should not be used to evaluate teachers. It is important that teachers do not feel overwhelmed with the task of assessment. Choosing one that is quick and easy will provide important and useful data, but will not be a laborious task for teachers. Explain that the data will provide benchmarks that will measure growth throughout the year and help to focus instruction on specific areas. This information can be utilized to group students for specific activities. It can identify students at risk that may require intervention or further testing. Teachers will be required to administer the mathematics screening assessment to the class, collect the data and submit the results by a given date. This will allow the data to be organized and ready to present for the next meeting.

Step 6: Review Data and Collaboratively Develop a Plan

Reviewing the data collected from the mathematics universal screening assessment will provide information on each student and their level of skills and concepts. It will identify the diversity in each class and help to determine where small groups or individual instruction may be required. Connecticut State Department of Education indicate that universal screening will also

provide evidence to assess how functional the instruction is at the school, stating that 80% of all students should demonstrate adequate progress throughout the school year (2012). "An inquiry-based use of information guides decisions and practice" (Lambert, 2002, p. 38). The data is examined to find answers and ask more questions. This will be a starting point for teachers to become actively involved in developing short term objectives, planning, and making decisions. Empower staff, encourage their participation and commitment to the mutually agreed upon objectives. In this way, student learning becomes a shared responsibility. Hallinger and Heck (2010) conclude that the analysis of their study, support the view that "collaborative leadership positively impacted growth in student learning" (p. 670). Obtaining teacher buy-in is crucial to successfully developing a collaborative community that shares in a common vision and works collectively to reach their goals. Beauchamp & Parsons (2012) noted that effective principals shared expectations with teachers and then stepped aside to allow teachers to work together, assume leadership roles and solve problems.

Step 7: Share Plan with Parents

Parents play an important role in the school community. They need to share in school goals, examine collected data, and learn how to effectively tutor students at home and in the classrooms (Lambert, 2002). "Such collaboration is building a sense of collective responsibility among students and parents for the accomplishments of all students" (Lambert 2002, p. 40).

Mathematics classrooms are very different in comparison to the classrooms that most parents are familiar with. It is not what students are learning in mathematics that has changed, it is how they are learning it. Not unlike the past, controversy remains between traditional teacher directed practices of rote memorization with a focus on the correct answer and current practices involving student discovery learning where importance is placed on problem-solving and

mathematical reasoning. Alberta Education has created guides, resources, and videos for parents to clarify the mathematics curriculum and the current instructional practices. A slide presentation at the school parent council meeting can be used as the initial step in involving parents in the mathematics community being created in the school. Sharing the school numeracy goal (*figure 7*), and Alberta Education's video guide for parents will be the beginning of building a collaborative mathematics community in the school.

WORKING TOGETHER
TO
BUILD A MATHEMATICS COMMUNITY

Our Goal:

"Students at our school will have numeracy skills or will be working towards achieving numeracy skills that meet or exceed curricular expectations"

Guide for Parents - Alberta Education Video
https://education.alberta.ca/teachers/program/math/videos.aspx

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Figure 7. Slide Presentation to Parents. This slide identifies school numeracy goal and provides a link to parent video related to mathematics curriculum in Alberta.

Helping parents understand the current mathematics curriculum and student-centered instructional practices will aid in developing a shared vision with all stakeholders. Working with parents, providing resources (Appendix B) and meeting regularly will help to develop their understanding of the expectations outlined in the mathematics curriculum and current instructional practices. This will alleviate concern and frustration they may be experiencing and will work towards building their confidence in supporting their child's learning. Successful practices build productive relationships with parents and the wider community (Leithwood, 2005). Parents emerge as instructional leaders as they share in setting goals, conferring with teachers and helping students at school at home (Lambert, 2002).

Step 8: Professional Learning

Learning is important to students, but equally important for teachers (Hallinger & Heck, 2010; Robinson, et al, 2008). "The education of mathematics teachers is an ongoing process. Being a teacher implies a dynamic and continuous process of growth that spans a career" (Martin & Speer, 2009, p. 403). Some teachers have made major changes to their teaching practices, others have made little changes, or nothing at all. Teachers should be encouraged and supported to "develop professionally through philosophical discourse with their peers, to plan and teach together, and engage in peer evaluation that is truly collaborative and non-threatening" (Davison & Mitchell, 2008, p. 151). One of the largest obstacles teachers encounter, is that teaching math today requires skills unfamiliar in traditional mathematics classrooms. Many of these teachers are teaching the same way they were taught (Davison & Mitchell, 2008). Professional learning that is focused on shared goals is beneficial to the improvement of the school. Teachers that align their own professional goals to the school goals become committed to moving forward and become responsible and accountable for their personal growth. Because the list for teacher

professional learning is endless, setting clear objectives should play a role in determining the learning agenda (Robinson et al., 2008). Alberta Education has provided several math related resources for educators on their website (appendix C). Reviewing the fact sheets for each of the seven interrelated mathematical processes (*figure 8*) and watching the companion video would initiate steps towards professional learning for the school community. By reviewing and understanding the provincial mathematics curriculum and vision of instruction, collaboratively, teachers will be able to identify the needs and determine additional professional learning that may be necessary.

The 7 Mathematical Processes Fact Sheet Series

This series of fact sheets gives an overview of what the seven mathematical processes can look like when embedded in the teaching and learning of mathematics. These fact sheets also have an accompanying video series which shows the processes in action in Alberta classrooms.

- Communication [C]
- Connections [CN]
- Mental Mathematics and Estimation [ME]
- Problem Solving [PS]
- Reasoning [R]
- Technology [T]
- Visualization [V]

Figure 8. Alberta Education Resource For Teachers. Outline of mathematical process strands with video links to clarify curriculum requirements.

Teachers need the freedom to take risk, be innovative and creative, and try new things. Effective leaders must respect teachers concern and caution in implementing new practices and understand

the real problems that teachers face. Teachers that have the opportunity and support to attempt new and creative ideas that moves teaching and learning forward.

Step 9: Maintaining and Sustaining the Collaborative Community

Establishing a school culture that collaboratively embraces change takes time and effort and maintaining it is important. Under an Instructional Leadership Model, developing and pursuing a goal becomes everyone's work and responsibility (Lambert, 2002). This collective responsibility is more effective in sustaining changes made to optimize teaching and learning (Lambert, 2002). To maintain the momentum of impending change, school leaders must encourage regular communication, to all stakeholders, related to ongoing objectives. This provides an opportunity for teachers to share their experiences and motivate others that may be experiencing difficulty or hesitant to take the risks involved in experimenting with creative ideas and innovative practices. Change is different for everyone. Some are excited and revitalized by change, while others are hesitant and resistant. Principals need to maintain a community of trust and support (Blase & Blase, 2000), where teachers have the freedom to risk, create, innovate and try new ideas (Beauchamp & Parsons, 2012). Regular communication with parents is important to maintain a positive, collaborative community that supports instructional change. Parents that understand the motivation for change are less likely to feel frustrated and negative towards the teacher and the school for the implementation of misunderstood or miscommunicated change. An effective leader builds a positive school community that encourages all stakeholders to take ownership of the learning. "If education is to change, it has to happen in the classroom" (Kilpatrick, 1997, p. 3). Teachers are key factors in any instructional change. Teachers need to understand and accept the changes before they can occur (Kilpatrick, 1999). This requires knowledge and understanding. Principals should expect, encourage and support on-going

professional learning opportunities (Beauchamp and Parsons, 2012), and allow the time necessary to foster collaborative learning between teachers. Fullan (2011) cautions leaders not to "load up on vision, evidence and a sense of urgency" (p. 66). In an effort to obtain buy-in, teachers need time to experience change and build on it with their peers (Fullan, 2011).

This plan provides a starting point for principals to initiate change to mathematic instruction, by developing a collaborative community within an instructional leadership framework. Each step outlines a key element required to build trust among stakeholders, open communication and collaboratively work to make changes that will continue to improve teaching and learning. If administrators are going to help teachers change, they must understand that "there are neither quick fixes nor easy answers to the improvement of teaching and learning" (Hoy & Hoy, 2006, p. 1). Change is difficult. It takes time, patience and perseverance. "Plans are only as good as they actions they inspire" (Fullan, 2011, p.67). This plan is simplistic with a clear focus on increased student achievement. The process can be clearly understood by all stakeholders and remains flexible. The role of the principal is to establish the foundation and initiate the creation of a collaborative group that will be empowered to continue changing and improving the teaching and learning. Barriers in any plan are inevitable. Stakeholders will have varying perspectives on the need for change and how changes will effectively be made. Overcoming the barriers encountered will rely on the open, mutually respectful communication established throughout this plan. Problems will need to be acknowledged and solutions sought. To motivate stakeholders and move change initiatives forward, it is important to seek solutions for difficulties encountered and celebrate the success along the way. Although this plan was developed to increase student achievement in mathematics, the steps are transferable across other subject areas. By developing a collaborative community that communicates openly and

frequently about instruction, the foundation is in place to support all changes needed to improve schools.

Chapter 4

The MEd program has given me an opportunity to develop a deeper understanding of the complexity of the teaching and learning process and how it is intertwined into the lessons, actions, and responses that I provide within my classroom. With the knowledge that I have acquired, I am better equipped to identify problems and seek solutions that move the learning forward in my classroom and in the school. Curriculum is no longer simply what I teach; it includes how I teach it. As I evaluate my continued personal and professional development journey, I feel better prepared to step outside my classroom and begin to engage in practices that will move my teaching forward. I value the relationships I have with my students, colleagues, parents and appreciate how they positively affect the quality of learning within the school environment. I no longer stand back and accept what I am told without question and investigation. My understanding of research has developed and my ability to determine quality information has expanded. I have become a better teacher, more knowledgeable in the education field and looking forward to using the skills I have acquired to enhance my professional career.

My understanding of curriculum was basically a prescribed number of learning outcomes that I was to convey to my students. I had no reason to give it much thought, except to wonder occasionally, who determined curriculum, how they selected the topics or what was the purpose of some of the information I was responsible for imparting on my students. Readings related to the explicit, implicit and null curriculum were enlightening, made sense and began to clarify my understanding. It was something I did know, but now I had the words to describe and identify what the components of curriculum actually were. Becoming aware of the learning that takes place in the classroom, regardless what you are teaching, made me more aware of the environment I was creating and teaching in. I began to pay closer attention to the culture of the

school and witnessing the effect it had on the learning. My lessons became more focused as I worked through the program of studies with a deeper understanding of curriculum. I began to consider more carefully the purpose of each lesson and how it would be taught rather than the concern focused on just the information. Reviewing the curriculum redesign document, Inspiring Action on Education, developed by the Government of Alberta, answered many questions related to instructional and curriculum changes that were taking place in our division, but brought forward just as many questions.

I have been teaching in Alberta for over ten years and I was very surprised that I had never heard of the document "Inspiring Action on Education" until I started my graduate studies. Within our program cohort, some divisions had already began a significant amount of work on instructional shifts that were outlined in this document, while others were not aware of the document or the implications it has for teachers working in Alberta. The discussions within our cohort and my understanding of curriculum gave me the incentive to focus on an area within my own classroom that I believed needed attention. I had an idea of the direction I wanted to take in my own teaching practice. I previously spent a number of years implementing balanced literacy strategies and more recently began using the 'Daily 5' framework to enhance my language arts program and strived to meet the needs of all students. Literacy goals were predominant in my 'Professional Growth Plan' and I filled my professional development opportunities with a variety of sessions, workshops and seminars. I was satisfied with my professional growth and believed that I was meeting the needs of my students. I have always believed that language arts and mathematics were key to learning. In light of what I was learning in the graduate program and the discussion related to Alberta Education's vision focused on literacy and numeracy, changing my teaching practices in mathematics would be my focus. As a result, teaching practices in

elementary mathematics classes would be the focus of my capstone project. Understanding the curriculum content is necessary in teaching, but equally important is the way it is taught or the pedagogy

Loughran's article (2013), clarified for me, the complexities of teaching and learning. I had not thought of pedagogy as a reciprocal relationship. I viewed pedagogy as a more linear process. Although I was reflective in my teaching practices, my experience in graduate studies clarified the process and I am able to identify and articulate elements of the learning process more effectively. I have learned that a teacher must disconnect from their role as a teacher and take on the role of a learner in an effort to identify the depth of student understanding. As our classrooms become more diverse, with a broad spectrum of ability in each and every classroom, it requires teachers to be aware of the teaching and learning interactions that constantly take place in the classroom and make decisions regarding the instructional practices based on these observations. As a result of my learning, I am more responsive to the needs of my students. Meeting the diverse student needs, within the inclusive classroom, adds to the complexity of the teacher's role in the pedagogical process of 21st century learning. My learning continued to propel my efforts forward, as a classroom teacher, to incorporate and redesign my teaching strategies to reflect a learning environment that was more student-centered. My focus in the classroom remained on mathematics and working to differentiate instruction to effectively meet the needs of all my students. I examined closely my teaching practices in mathematics and carefully considered the way I use the textbook resource. I understand how reliance on a textbook and teacher-directed practices in mathematics, can be related to a teacher simply not having the content knowledge or the confidence to risk making changes. Despite a strong desire to change my teaching practices in mathematics, the task can be extremely difficult when you

work towards change on your own. I understand the improbability of sustainable change, when working in isolation.

Teachers currently work collaboratively with parents, principals, educational assistants and school counsellors to meet the educational needs of the students. Relationships are built in an effort to provide ideas, strategies, support and feedback required to maximize student success. I believe that the same collaborative framework is necessary for teachers to enhance their own learning. Teachers need opportunity to learn and develop in a collaborative process with their colleagues. Through the research I have done in the graduate program, I understand the importance of teacher learning and consider the collaborative process between teachers a vital element to sustainable changes in education. The collaborative process provides an endless resource of creative and innovative ideas. This provides opportunity for teachers to work together in an effort to identify problems and discover solutions. The opportunity to discuss issues within the cohort group demonstrated for me the value of a professional learning community. I value to opportunity I had, building relationships with colleagues in the cohort group, and having educators identifying similar issues and discussion related to alternative strategies. I quickly discovered that the mathematics curriculum and teaching practices were problematic for many others and the basis of controversy and debate. It was through the collaboration with colleagues that I discovered valuable resources that could be implemented into my practices and aligned with the vision for 21st century learning. Collaborative practices are beneficial but require the support of the leadership team to maximize effectiveness.

I have come to realize that system wide, sustainable change takes more than an individual's desire to do so. When considering the reform initiatives outlined in the "Inspiring Action on Education" document and the complexity of teaching and learning, I have come to

understand the considerable amount of time and planning it takes to move change initiatives forward. There are no easy answers when changing or improving teaching. Change has to be understood and accepted before it can be effective and sustainable. According to Kilpatrick (2012), reformists underestimated the importance of including teachers, parents and students in reform initiatives, and as a result failed to implement and sustain any change. This era in mathematics curriculum demonstrated clearly that top-down, mandated change will not work without buy-in from teachers. Teachers are at the center of instructional change and must understand and believe in the reason(s) for making change. I understand how the relationship between teaching staff and administration influences educational change.

Leadership is vital to the success of school improvement and moving schools forward to meet the changing needs of the students. The readings and assignments in the EDCI 591 - Instructional Leadership and Change gave me exposure to a new perspective. My experience in leadership is limited to working with student teachers and mentoring new teachers to the profession. Graduate studies have given me insight to the leadership role and how it encourages or inhibits growth and change. Collaborative planning and learning is extremely beneficial to the growth of teachers, but strong leadership that encourages and persuades without pressure is equally beneficial. A leader that shares decision making with the staff and follows through on decisions that are made as a collaborative effort gains respect and trust from the staff. Effective leadership has the best interest of the students and learning at the center of their focus. Reading Michael Fullan's, Change Leader (2011), gave me an opportunity to evaluate my leadership approach and reflect on my leadership qualities, identifying my strengths and weaknesses. Initially, my intentions for taking the Masters Program were not specifically to qualify myself for a leadership role. As I reflect on my experiences over the past two years in graduate studies, I

would consider myself better prepared to take on leadership responsibilities if the opportunity presented itself. The clarity to which I see the different roles within the school context, have strengthened my understanding of the integral roles that work simultaneously to create an effective learning environment.

The reading and assignments in the graduate studies programs has broadened my understanding and appreciation for education. I have strengthened my skills and become more efficient in collecting information from sources that are valid and credible. As I continue on my path as a committed lifelong learner, effective and efficient research skills will be invaluable. The reading and research I have completed over the past two years has answered an immense amount of questions, yet created many more. The learning journey is never over, the focus just changes.

I am excited to take what I have learned and focus on making changes that will improve the teaching and enhance the learning within my classroom. I believe that if nothing else, I have become a better teacher as a result of my graduate studies experience. I have a deeper understanding of the teaching/learning process and will take what I have learned, reflect on my practice, evaluate student learning and make informed decisions regarding changes that may be necessary. As I review the program of studies, consider the reform initiatives set in motion by Alberta Education; I have a much clearer personal vision of where I need to be as a teacher. Meeting the needs of the every student is extremely important to me and I feel that I am better equipped now than I was at the beginning of my graduate studies.

Currently, I am working with teachers collaboratively on ideas to improve the quality of teaching and learning within the school. My capstone project was developed as I worked through the process of developing and changing my teaching practices in mathematics. In the

beginning my focus was specifically on my teaching practices. Frustration quickly developed as I encountered difficulties and faced the inability to work through them on my own. Sharing ideas with colleagues is very helpful; however, working with a group that shares a common goal is substantially more beneficial. Changing my teaching practices was more difficult that I had expected. I struggled to understand how it would be possible to change the practices of other teachers. As I reached out to my colleagues at school, engaged in several conversations with my principal and reflected on the applicable discussions within the graduate program cohort, my focus began to shift. The purpose of everything I do in my classroom is centered on the students and their learning. If my goal was to improve student achievement in mathematics, the changes to my teaching practices would follow as a result of the reciprocal process involved in teaching and learning. Through a collaborative effort, I began to understand how I could implement a plan that would likely initiate substantial change within the school.

My plan is to work with the leadership team at school to develop a collaborative community focused on increasing student engagement and achievement in mathematics. I am excited to work with the principal and develop a goal for our School Education Plan, that will focus on numeracy and align with the district and provincial vision for education. Sharing this goal with staff, in an effort to obtain teacher buy-in, will be my primary focus. I am interested and excited to work with the teachers to share innovative ideas. We are currently working together, teachers and administration, to develop a flexible timetable that will accommodate literacy and numeracy in the mornings of each day. The proposed framework will allow for the movement of students within multi grade groupings. Teachers will work together to create homogeneous and heterogeneous groupings that will best meet the needs of the students. I am

fortunate to work with an administration team that supports change, values collaborative practices and works within an instructional leadership model.

I am interested in working more actively with the site-based professional learning at the school. Sharing in the development of new, creative and innovative ideas for the classroom, identifying problems and seeking solutions generates enthusiasm and is inspiring. Working with teachers, parents and students to build a positive learning environment is challenging, yet rewarding. I will apply the knowledge, skills and confidence I have gained through the graduate studies to new challenges I encounter.

For other educators interested in a project related to the mathematics field, I would recommend that they seek out individuals that share a similar passion for mathematics, keep the research organized and focused, and be certain that you have a passion for mathematics.

Discussing current trends and having a 'sounding board' is beneficial to clarifying your thoughts and solidifying your ideas. Debating some of the current issues helps to strengthen your stance and viewpoint on the subject. Having an opportunity to discuss mathematics with a teacher that works with a different grade level is enlightening. If you are an elementary mathematics teacher, the perspective of a teacher whose experience is related to high school mathematics, is very interesting and often presents issues that you had not considered.

Mathematics has a long history of reform and debate. Current issues today, have similarities to issues encountered in the past. The amount of articles and books on the topic of mathematics is overwhelming. I would recommend having a clear focus determined before the research begins. It was easy to slip away on a tangent and find myself lost in the research and moving away from my intended focus. Being organized from the beginning and developing an effective method of cataloguing your resources is important in saving valuable time.

Find your passion! Be certain that the topic you are pursuing is interesting to you. Having a topic that is relevant to what you are pursuing, or would like to pursue in your career, helps to keep you focused, engaged and enthusiastic about your project. It is a considerable amount of time and effort put into the completion of a capstone project. Working on a project that you find fascinating can be rewarding.

The graduate studies program has pushed me to grow professionally and personally. I have accomplished much more that I had anticipated I would in the beginning. In addition to the knowledge and skills that I have acquired over the two years in this program, I have had the opportunity to meet and build valuable relationships, personally and professionally, with a cohort group of educators. I am excited to move forward in my professional career, better equipped and more knowledgeable.

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Appendix A

SCHOOL EDUCATION PLAN

SCHOOL GOAL

- Students at ABC Elementary School will have numeracy skills or are working towards attaining numeracy skill that meet or exceed curricular expectations

DISTRICT GOALS

- Students have engaging and collaborative learning experiences that prepare them to be active, creative, and knowledgeable participants in a global society
- students have engaging and collaborative learning experiences that prepare them to be critical thinkers and problem-solvers
- students are global citizens who respect and value diversity
- ALL students have their individual needs met within inclusive learning environments

PROVINCIAL GOALS

- success for every student
- high quality education through collaboration and innovation
- success for First Nations, Metis, and Inuit students

STRATEGIES

- teachers will work collaboratively to implement a schoolwide numeracy program
- staff will assess students' to identify prior knowledge for each strand of the mathematics curriculum at each grade level
- staff, students and parents will be trained to work with students to enhance conceptual understanding of foundational math concepts

PERFORMANCE INDICATORS

- students that require intervention will increase numeracy skill
- higher student achievement
- increased student engagement

Appendix B

Retrieved from: https://education.alberta.ca/teachers/program/math/parents/links.aspx

Fact Sheets & Useful Links

Kindergarten to Grade 9

Fact sheets for Parents courtesy of the Alberta Regional Professional Development Consortia

- How does today's mathematics classroom differ from what I experienced?
- How can I help my child look forward to math?
- How can technology support the learning of mathematics?
- Why is the focus in my child's math class on problem solving?
- Why are elementary students studying algebra?
- What does it mean for my child to communicate in math?
- What is “mental mathematics”?
- What is number sense?
- What are manipulatives?
- How can literature support mathematics?
- What are personal strategies and formal algorithms?

Appendix C

retrieved from: https://education.alberta.ca/teachers/program/math/educator.aspx

Welcome to the mathematics page for educators!

We have organized our web pages into three groups, students, parents and educators, with the most up-to-date information about the learning and teaching of mathematics that we hope you find useful.

Kindergarten to Grade 12 Mathematics programs

Alberta is recognized worldwide as a leader in the development of quality curriculum. The Kindergarten to Grade 12 mathematics program maintains this standard by integrating current research, developments and trends in mathematics education.

The mathematics programs of study were developed in collaboration with teachers, administrators, parents, business representatives, post-secondary institutions and others to ensure they meet the needs of Alberta students.

The Mathematics Kindergarten to Grade 12 programs of study are based on the Common Curriculum Framework (CCF) under the Western Northern Canadian Protocol. The CCF identifies beliefs about mathematics, general and specific student outcomes, and achievement indicators.

To learn more about the mathematics programs, we encourage you to take a look at the Programs of Study.

Mathematics Learning

Students learn by attaching meaning to what they do. At all levels, students benefit from working with a variety of materials, tools and contexts when constructing meaning about new mathematical ideas.

The learning environment should value and respect the diversity of students' experiences and ways of thinking, so that students are comfortable taking intellectual risks, asking questions and posing conjectures.

Students need to explore problem-solving situations in order to develop strategies and become mathematically literate. They must realize that it is acceptable to solve problems in a variety of ways and that a variety of solutions may be acceptable.

The Seven Mathematical Processes

The seven mathematical processes are critical aspects of learning, doing and understanding mathematics. Students must encounter these processes regularly as they learn mathematics in order to achieve the goals of mathematics education.

The mathematics programs of study incorporate these seven interrelated mathematical processes, which are to permeate the teaching and learning of mathematics. Students are expected to:

- use *communication* in order to learn and express their understanding
- make *connections* among mathematical ideas, other concepts in mathematics, everyday experiences and other disciplines

- demonstrate fluency with *mental mathematics and estimation*
- develop and apply new mathematical knowledge through *problem solving*
- develop mathematical *reasoning*
- select and use *technology* as a tool for learning and for solving problems
- develop *visualization* skills to assist in processing information, making connections and solving problems.

All seven processes can be used throughout the teaching and learning of mathematics. However, the processes identified in the Specific Outcome are to be used as a primary focus of instruction and assessment. To learn more about the processes and see them embedded in a classroom, please view the "7 Processes" series of videos and fact sheets.

Goals for students

The main goals of mathematics education are to prepare students to:

- solve problems
- communicate and reason mathematically
- make connections between mathematics and its applications
- become mathematically literate
- appreciate and value mathematics
- make informed decisions as contributors to society

Students who have met these goals:

- gain an understanding and appreciation of the role of mathematics in society
- exhibit a positive attitude toward mathematics
- engage and persevere in mathematical problem solving
- contribute to mathematical discussions
- take risks in performing mathematical tasks
- exhibit curiosity about mathematics and situations involving mathematics.

Teachers can assist students in attaining these goal by developing a classroom atmosphere that fosters conceptual understanding through:

- taking risks
- thinking and reflecting independently
- sharing and communicating mathematical understanding
- solving problems in individual and group projects
- pursuing greater understanding of mathematics
- appreciating the value of mathematics throughout history.