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Curricular pathways to Algebra I in eighth grade

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CURRICULAR PATHWAYS TO ALGEBRA I IN EIGHTH GRADE

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DEDICATION

To my mom, my children, and David

for their patience, love and support in this endeavor

To my dear friends Chris and Kay

for steadfast encouragement over many cups of tea

and

To my furry children

for hours of companionship at my desk

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ABSTRACT

Nationwide, schools are pushing for more students to take Algebra I in eighth grade, prior to formally entering high school. The algebra-for-all movement has been intended to alleviate equity issues which held minority and low-income students back from entering a college-preparatory path in high school. Students with the needed content, processing, and cognitive skills benefit from this early entry to high school mathematics; however, students who are not prepared for higher level mathematics struggle and continue to have difficulty with mathematics into high school as well.

In Virginia, Algebra I serves as the first high school credit-bearing mathematics course. While Virginia has specific standards for students to demonstrate proficiency at each grade level prior to entering Algebra I, there is a need to either skip one grade level of mathematics or to compress the prescribed mathematics curriculum into a shorter time period in order to complete the course as an eighth grade rather than as a ninth grade student. Each school division decides how this process will take place.

This study examined the curricular pathways used by Virginia school divisions to prepare students for successful completion of Algebra I by the end of middle school through either grade skipping or compressing the curriculum. Entry points to the curriculum were compared, as well as the placement criteria considered in putting students on this curricular pathway. The study

sought to determine if there is a relationship between curricular pathways used and scores on the Algebra I, End-of-Course Standards of Learning test.

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CURRICULAR PATHWAYS TO ALGEBRA I IN EIGHTH GRADE

Chapter 1: The Problem

Algebra has moved from being a course taken by those students who are college-bound to a course that is required of all students in high school. In the 1980s, students could graduate from high school without ever taking Algebra I or a higher level mathematics course. *A Nation at Risk* (1983) focused the country's attention on the lack of rigor in American high school mathematics. At the time of the report 35 out of 50 states required only one year of mathematics for graduation (National Commission on Excellence in Education, 1983). The commission recommended increasing the number of courses required for high school graduation, including coursework that would prepare high school graduates to understand algebraic concepts.

Educational research through the 1990s supported the idea of increased rigor in mathematics. As of 2013, 42 states now require three credits of mathematics for graduation, and 16 of those require four credits (Stoelinga & Lynn, 2013). Previously Algebra I was often the final mathematics course for some high school students, as other lower-level mathematics courses were used to satisfy graduation requirements. Most states, including Virginia, now require mathematics courses at or above the level of Algebra I to satisfy graduation requirements(Achieve, 2010; NCES, 2009). Algebra I is the gateway course to the higher mathematics course students need to take to graduate from high school prepared for college or the workplace.

It is no longer a matter of whether or not students should take Algebra I, it is a matter of *when* they should take it. Providing Algebra in eighth grade or earlier allows the student more time to take more math classes in high school and opens up opportunities to finish Calculus prior to entering college (Achieve, 2008; Schneider, Swanson, & Riegle-Crumb, 1998). Algebra I is also a prerequisite for other coursework, such as computer programming and science classes and mastery of Algebra is crucial to success on the SAT exam (de Vise, 2008).

The National Council of Teachers of Mathematics (NCTM) takes the position that all students should have access to an authentic Algebra class when they have demonstrated success with prerequisite skills, not necessarily at a specific grade level (NCTM, 2008). Early research into early-Algebra was promising, showing that students who took Algebra in eighth grade went on to take more mathematics in high school (Ma, 2000; Smith, 1996). During this same time period, equity issues in mathematics course placements came to light, showing that many minority and low socio-economic students were denied access to early Algebra even if they were qualified academically (Spielhagen, 2008; Mulkey, Catsambis, Steelman, & Crain, 2005). Large urban districts in California, Chicago, and Charlotte, moved to place more disadvantaged students into Algebra in eighth grade, often through enacting a sweeping algebra-for-all policy which required all students to take Algebra in eighth grade. While the policy shift did benefit some students who had previously been denied access to this course (Ma, 2005), it has also adversely affected other students who were not prepared to make the academic leap to Algebra (Stoelinga & Lynn, 2013; Murray, 2012). Simply providing access to the course does not ensure success.

Students who are well-prepared to take Algebra have been affected as well. Initial research into early Algebra conducted in the 1990s showed the benefits of early Algebra course taking. The students in these studies were placed into Algebra class ahead of their peers due to their high mathematical abilities, creating homogeneous classroom settings that allowed for higher-level teaching and learning (Slavin, 1993). Algebra-for-all policies have created more heterogeneous groupings in the eighth grade Algebra classroom, which has not boded well for gifted students. Research shows that as remedial math classes are eliminated and more mixed ability classrooms are created, skill levels and test scores declined for high-level students (Nomi, 2012).

The issue at hand is not the offering of an Algebra I course in eighth grade, as research has shown that this policy benefits students in many subgroups, in particular students from low socio-economic backgrounds (Gamoran & Hannigan, 2000). The issue is placing ill-prepared students in eighth grade Algebra without additional needed support, thereby setting them up for failure which could affect both their academic achievement in high school and their attitude towards taking more mathematics in high school (Loveless, 2013). Students should be well-prepared for Algebra, having been introduced to algebraic concepts and skills across the K-8 curriculum (NCTM, 2008). There is no research that demonstrates that a specific multi-grade sequence of topics assures success in Algebra I (National Mathematics Advisory Panel (NMAP), 2008b, p3-43). However, based on international educational systems and current research on beginning Algebra I in middle school, it is clear that better preparing more students to attempt the course at that time would benefit all (NMAP, 2008b, p.3-47)

Statement of Purpose

The purpose of this study was to determine the curricular pathways used by school divisions in one representative state – Virginia. As an early adopter of state standards, Virginia has had time to not only establish standards but also to edit and revise them over the years (Virginia Board of Education, 2009). Virginia's mathematics standards are well-aligned to NCTM's standards, and revisions made to the standards in 2009 brought about alignment with the National Mathematics Advisory Panel (NMAP) recommendations as well. Virginia scores above the national average on the National Assessment of Educational Progress (NAEP) in eighth grade mathematics (National Center for Educational Statistics, 2013). The National Center for Educational Statistics (NCES) credits Virginia with significant increase in Grade 8 mathematics achievement since 2005 (NCES, 2013).

While not officially advocating for an algebra-for-all policy, the Virginia Department of Education (VDOE) made revisions made to the 2001 standards to redistribute pre-requisite topics for Algebra I to earlier grades, thereby enabling all students who complete through Math 7 to be better prepared to make the move to Algebra I rather than Math 8 (VDOE, 2009).

The study focused on policy decisions made by Virginia school divisions to enable students to take Algebra I in eighth grade. Entry points to the pathway as well as the type of placement criteria used (i.e., grades, SOL scores, placement tests, teacher evaluation and parent input) were examined. In addition the type of pathway (i.e., compressing the curriculum versus skipping content) and which particular iteration of pathway were also determined. The researcher also inquired as to if the policy had changed during the past three school years (2011-2012, 2012-2013, or 2013-2014). These curricular pathways were then correlated to student performance on the Virginia Standards of Learning (SOL) Algebra I End-of-Course (EOC) test to determine if there was a relationship between the curricular pathway used and successful SOL scores.

Because of the increased rigor of the SOL tests resulting from changes in the 2009 *Standards of Learning* (which closely mimic the Common Core State Standards for Mathematics), Virginia school divisions may be facing a need to re-examine their policies to prevent course failures which could be a deterrent to a student's progress in high school mathematics and which also impact Adequate Yearly Progress (AYP) for the school and the division.

Research Questions

This study examined the curricular pathways of students taking Algebra I in the eighth grade in Virginia. To that end, the following research was addressed:

1. At what grade level do students enter the curricular pathway to take Algebra I as an eighth grader?
2. What placement criteria are considered for a student to take Algebra I as an eighth grader?
3. What is the curricular pathway to taking Algebra I in eighth grade? (That is, is this accomplished by compressing the amount of time spent in teaching the full K-8 mathematics curriculum or by skipping a grade level of mathematics?)
4. To what extent did school divisions change their curricular pathway to Algebra I in eighth grade?
5. What is the relationship between the curricular pathway used and scores on the Virginia Algebra I End-of-Course (EOC) Standards of Learning test?

Significance of the Study

This study was significant for several reasons. There was a lack of research in Virginia about which curricular pathway leads to the best results on statewide testing for eighth graders in Algebra I. While the state provided curricular standards and frameworks for each grade level, school divisions decided how to implement this on the local level. This study helped school division leaders make informed decisions about local curricular frameworks that would better prepare their eighth grade students to succeed in Algebra I. That in turn would help better prepare students for success in further high school mathematics coursework, such as Algebra II, which is now a requirement for high school graduation in Virginia (VDOE, 2013b).

School divisions were able to see how curricular pathways and placement criteria related to test scores. While school division leaders meet regularly (for example, Virginia Council of Mathematics Supervisors meetings are held twice a year), they are sometimes mum on what their division actually does and even less forthcoming when perhaps their scores are not as good as other divisions. This study provided a basis that can be used to examine school division policies in regards to the optimal curricular pathway through upper elementary and middle school mathematics so that students can be successful in eighth grade Algebra I.

While there is an abundance of writing on the topic of Algebra I in middle school, there were currently no definitive studies about which particular mathematical content students need to be successful in Algebra I in eighth grade, so this study added to the body of knowledge on this topic.

Justification

Research has shown that students who take Algebra in eighth grade go on and take more mathematics in high school (McFarland, 2006; Schneider et al., 1998; Stevenson et al., 1994). But it has also been shown that forcing a child into an Algebra I class before he/she is ready can be detrimental (Stoelinga & Lynn, 2013; Clotfelter, Ladd, & Vigdor, 2012; Nomi, 2012). If a student is unsuccessful in Algebra I in eighth grade, that can affect his/her perception of ability in mathematics which in turn can lead to him/her taking fewer math courses in high school (Stoelinga & Lynn, 2013; Murray, 2012). Likewise, success in Algebra I in eighth grade builds the student's confidence in succeeding in higher math courses (Ma, 2000).

Much of the research on the topic of eighth grade Algebra was done 15 or more years ago. At that time, only top academic students were selected to take Algebra I in middle school. As research into equity issues concerning access to Algebra I became a national focus, more students are now either voluntarily enrolling in or mandatorily put into Algebra I classes by eighth grade. While early research showed that taking Algebra I in the eighth grade did increase the amount of math classes completed in high school for those students (Ma, 2000; Smith, 1996), current research is not giving the same definitive results (Loveless, 2011). The clientele for Algebra I in eighth grade has changed over the past decade, and more research is needed to determine what the most beneficial educational outcomes for them.

Increased usage of standardized testing, changes in state standards and now the enactment of national standards, combined with an upsurge in mathematics requirements for graduation have created a new landscape of mathematical rigor and accountability for schools and students.

Operational Definition of Key Terms

The following key terms will be used in this study:

- *accelerated track*: Completing coursework in less than the normal amount of time either by skipping through grades at a faster than average rate or by condensing the curriculum. For mathematics in Virginia this refers to a student who is *one or more* years ahead of the intended curriculum.
- *algebra (begins with a lower-case a)*: This term refers to the mathematical strand (topic) rather than a specific course in this subject. The term "algebraic" is used to denote occurrences where this topic is addressed in all K-12 grade levels.
- *Algebra* or *Algebra I (beings with a capitalized A):* A specified high school credit bearing course which addresses concepts typically found in an introductory algebra course.
- *algebra-for-all:* A policy which either requires all students to enroll in Algebra I in eighth grade or allows self-selection into Algebra I in eighth grade independent of previous mathematics achievement.
- *Algebra Readiness Diagnostic Test (ARDT)*: A 30-item, computer-adaptive test used to assess content mastery for a particular grade level. Virginia specifies that the test should be used to determine the need for student intervention and identifying specific content strands needing remedial instruction (VDOE, 2013).
- *Calculus*: A high school credit-bearing course on the topic of calculus.
- *Common Core State Standards – Mathematics (CCSS-M):* Mathematical standards developed with sponsorship of the National Governors Association Center for Best Practices and the Council of Chief State School Officers to create a national K-12 curriculum.

- *curriculum compressing*: Moving through a prescribed curriculum in a shorter than expected amount of time according to policy decisions made by a school or school division.
- *integrated curriculum:* An approach in which the high school mathematics topics of Algebra I, Geometry, Algebra II, and Pre-calculus are presented in some order other than the customary sequence of year-long classes shown above.
- *Orleans-Hanna Prognosis Test:* A normed problem-solving assessment used to help predict students' readiness for algebra courses. The test product was created by Pearson (1998) and is typically given to students in grades 4 -8.
- *Scholastic Math Inventory (SMI)*: A computer-adaptive assessment that monitors growth through Algebra I.
- *secondary course:* A high school-level course of study that awards high school credits. In addition to providing content and knowledge, secondary courses encourage students to develop higher level thinking skills such as problem solving, critical analyses and syntheses of ideas (VDOE, 2009).
- *secondary school transcript:* An official list of secondary courses taken by a student, except those purged from a middle school record in accordance with 8VAC20-131, *Regulations Establishing Standards for Accrediting Public Schools in Virginia*, showing the final grade received for each course (VDOE, 2009).
- *skipping:* Purposefully omitting mathematical topics from the curriculum via school division or school policy decisions.
- *Standards of Learning (SOL)*: Standards that are approved by the Virginia Board of Education.

- *Standards of Learning Tests:* Criterion-referenced assessments approved by the Virginia Board of Education for use in Virginia assessment programs that measure attainment of knowledge and skills required by the Standards of Learning.
- *strand:* A specified area of topics in mathematics. Virginia uses the mathematical strands of Number & Number Sense; Computation & Estimation; Measurement & Geometry; Probability & Statistics; and Patterns, Functions & Algebra.
- *verified credit:* A credit awarded for a course in which a student earns a standard unit of credit and achieves a passing score on a corresponding end-of-course SOL test. A standard or verified credit awarded upon completion of coursework that is required for graduation from high school in Virginia.
- *Virtual Virginia:* A program that offers courses online, primarily pre-Advanced Placement, honors, and AP classes as well as academic electives and world languages. The program is designed to meet the needs of students who otherwise would be unable to take these courses due to a lack of availability or scheduling conflicts within their school.

Delimitations of the Study

This study had several delimitations:

- The study was limited to school divisions in the Commonwealth of Virginia. There were differences in curriculum content and pacing compared to other states' standards and to the Common Core State Standards for Mathematics (CCSS-M).

- As a state, Virginia had not yet adopted the algebra- for- all policy to which a number of other states already adhere. As such, most eighth grade algebra classes in Virginia represented students who were selected to participate rather than mandated to do so.
- This study focused on curriculum compression and skipping content that occurs for Math 5, Math 6, Math 7 and Math 8 (VDOE, 2009) so that students can take Algebra I in eighth grade. Some middle school students may have learned mathematics via both curriculum compressing and skipping curriculum in order to take Algebra I as a seventh grader, but they were not sampled in this study.

Limitations of the Study

This study had several limitations:

- This study was representative of rural, urban, and suburban school divisions without complete representation of all divisions in Virginia. While school division testing data is public record, not all school divisions completed the survey on curricular pathways.
- Survey responses relied on the integrity of the person completing the survey. The survey respondent may or may have been well-versed in mathematics education. Some districts have a designated mathematics supervisor. Others divisions have personnel from central office who fill that role in addition to other duties. Some school divisions do not have designated curriculum leadership and this duty falls to the superintendent or his/her designee.

- While following the same standards (VDOE, Algebra I, EOC), there were differences in the amount of instructional time and the methods of teaching used in a middle school Algebra I class.
- Because of these issues and the limited nature of the study, the results cannot be generalized to populations that differ significantly from those found in Virginia.

CHAPTER 2: LITERATURE REVIEW

Algebra has been a point of contention since its origins in K-12 education. Debate has ensued for over a century as to the content of Algebra I as a course, and the educational policies which dictate its inclusion in K-12 classrooms. Algebra I has served as both a gateway to opportunity and a barrier to educational advancement for many students over the years. As is often the case in educational policy, the pendulum continues to swing.

This literature review begins with a chronological perspective of the research, policy, and practice which led to the current status of Algebra I being taught as a middle school course. The next section will examine the research on the mathematical background and skills students need to be successful in an Algebra I class in middle school, both from a content and a practice perspective. The following section will examine research on the benefits and drawbacks of following this academic route. The final section focuses on the current state of affairs in Virginia regarding policy, state standards, and the curricular pathways and placement criteria school divisions are considering when they put students in Algebra I in middle school.

The Evolution of Algebra as a High School Course

The Progressive Era (Turn of the 20th century through the 1930s)

The history of studying algebra as a formal course of study in American high schools begins more than a century ago. Mathematics coursework prior to Algebra I in high school was based on arithmetic and computation. Most students did not begin to study algebraic concepts until they took the formal class in high school, as was also the case with geometry. The study of mathematics was seen as a way to develop mental discipline – the belief that if one exercises his/her mind, the mind will strengthen. Psychologist Edward L. Thorndike's experiments in the early 1900s cast doubt on the theory of mental discipline, championing the belief that children could learn on their own without always having direct instruction from a teacher. Known as "active learning," Thorndike's work would become justifications for the mathematics reform movement of the early 20th century.

The great debate of practical versus abstract mathematics began in the 1910s and continues to this day. In 1915 William Heard Kilpatrick – a distinguished professor at the Teachers College at Columbia University -wrote a paper that became widely accepted in the education community. At that time, leaders in education were moving away from academic scientism to a progressive functionalism view of education (Glatthorn, Boschee & Whitehead, 2006). Working with a committee organized by the National Education Association's Commission on the Reorganization of Secondary Education, Kilpatrick asserted that the teaching of algebra should be highly restricted and considered only for its practical value or for students who chose independently to study it. Kilpatrick stated that "we have in the past taught algebra and geometry to too many, not too few" (Klein, 2003, p.8).

This viewpoint was echoed by Superintendent Isaac O. Winslow from Providence, Rhode Island, who noted that "high schools are no longer select. They have become the schools of the people and must be conducted accordingly" (Winslow, 1916, p.1). Enrollment in secondary schools increased, but not all students planned to attend college afterwards. The public began to view all high school subjects as life preparation for good citizens rather than just as a means to accumulate knowledge that would then be used in college study. Mathematics instruction would go beyond learning theory in mathematics, as students were expected to transfer this knowledge into practical applications in the real world. Winslow believed that students should have as much mathematics as practical for "ordinary conditions," and that "ordinary" students did not have the mental discipline needed for the study of higher mathematics such as algebra and geometry. As such, Winslow recommended only one year of mathematics be required of all students out of "respect for their ancestors." (Winslow, 1916, p.4).

Kilpatrick's committee included only educators, spurring outrage in the community of mathematicians. A National Committee on Mathematical Requirements (NCMR) was formed by the Mathematical Association of America in 1916 in response to public concern about increasing failure rates and decreasing enrollment in classic mathematics courses. Unlike Kilpatrick's committee, which included only educators and not necessarily anyone who taught mathematics, this committee was made up of mathematicians and secondary mathematics teachers. The committee's task was to examine mathematics education from secondary school through college and make recommendations on how to improve the teaching and curriculum. The Committee published *The Reorganization of Mathematics in Secondary Education* (NCMR, 1923), which became known as the *1923 Report.* This publication stated that Algebra was important to every educated person (Klein, 2003).

The NCMR also endorsed the Junior High movement of 1920 as a new educational model which would increase the efficiency of teaching mathematics (NCMR, 1923). Prior to this, schools were organized primarily in a first through eighth grade school, followed by high school which included grades nine through twelve. Plan A of NCMR's report, which was one of five possible plans for a junior high course sequence, recommended the teaching of "algebra and applied arithmetic" (NCMR, 1923, p.29) in the eighth grade, followed by a continuation of algebra, trigonometry, and geometry in the ninth grade. According to this plan, teaching of arithmetic should conclude by the end of eighth grade. Once students entered high school, they would be encouraged to continue their mathematical studies with offerings through elementary calculus. The committee was very clear that "secondary mathematics courses should not be planned only to satisfy college entrance requirements," so as to not introduce conflict between the needs of students who go to college and those who do not (NCMR, 1923, p.29).

It should also be noted that even at this early stage of educational policy, the committee was already concerned about international competition. The report included a research chapter on the arrangement and content of secondary mathematics courses in foreign countries, noting important points of difference between them and the U.S. Of particular note was that most European countries began study of secondary mathematics topics at a much earlier age, usually around 9-10 years old, and that students received longer periods of intensified study on a particular topic (Bidwell & Clason, 1970). The authors believed that this contributed to German dominance in scientific fields.

The *1923 Report* set off a trend in educational research focusing on the aims of mathematics and utilization of an organizational approach to curricular reform which continued into the 1950s. While the committee's recommendations did find their way into textbooks being written for the new junior high model, no major change in practice occurred largely due to the Great Depression and the inertia which surrounds change in public education. The Report's goal of including more than just arithmetic in a general education class for all junior high students was not embraced at a time when many Americans were out of work and struggling to survive. As the national economy suffered so too did school finances, and most school districts had no funds available to implement the proposed changes (Tyack, 1984). In addition, the National Council of Teachers of Mathematics (NCTM) was founded in 1920 as an organization to counteract the progressivist educational agenda. Ironically, NCTM in later decades would become a champion of many of the child-centered teaching practices that Kilpatrick suggested.

Kilpatrick's report exerted much more influence than the *1923 Report*, as was echoed in educational articles that followed through the next two decades. As the Great Depression set in on the nation, the number of students in American high schools swelled, yet the career prospects for them after graduation diminished (Garrett, 2003). Traditional school mathematics was viewed as a relic of the past which provided no benefit to the current generation. Enrollment in higher mathematics courses in high schools continued to drop, from 56.9% of students completing Algebra in 1910 to just 30.4% in 1934 (Klein, 2003, p.5). Progressivism was taking hold in public education with the belief that the school curriculum would be determined by the needs and interests of the students instead of the traditionally taught subjects. As many of those students would be entering unskilled jobs following graduation, the need for a college-preparatory curriculum would not be required by the majority of students, particularly in mathematics, so it seemed unnecessary to subject them to the higher-level cognitive demands of upper level mathematics if they were never going to put it into use.

The public, including education experts, supported this rationale, particularly in a time when unemployment was at an all-time high. In the January 1933 edition of *Education,* M. Evan Morgan stated "in my own experience, a year of bookkeeping taken after majoring in college mathematics....has had more value in school, business, and home than all of the other." (Morgan, 1933, p.276). David Snedden, a founder of educational sociology and later Commissioner of Education for Massachusetts, stated that "Algebra...is a nonfunctional and nearly valueless subject for 90 percent of all boys and 99 percent of all girls – and no changes in method or content will change that." (Klein, 2003, p.9). It would take the unintentional assessment of mathematical learning as the U.S. Army tested draftees to change the public's mind.

War Changes Everything

By 1940, almost three-fourths of 14-17 year olds in the United States attended high school, with about half graduating (Stanic, 1986). The onset of World War II suddenly increased the demand for young men and women who were mathematically capable to fill military and industrial jobs. An unfortunate ramification of the decrease in cognitive level of demand in secondary school mathematics during the 1930s became a public scandal when the U.S. Army found itself having to provide training in arithmetic to army recruits who had not mastered the skills taught in public schools (Klein, 2003). U.S. Navy Admiral Chester W. Nimitz's letter of 1942 lamented the 75% failure rate of naval officer candidates in navigation and articulated the dependence of the U.S. military establishment on the mathematics education learned in schools (Garrett, 2003). While Nimitz was not an educator himself, his high profile during World War II attracted public attention to this problem. Military officials tasked teachers and principals with the vital role of adequately training our soldiers for duty. In an era before computers, the ability to quickly and accurately complete calculations, utilize formulas, read maps and schematic drawings, and create geometric constructions were essential to military operations. While this push was not a full return to the traditional algebra and geometry meant for college-bound students, it was a another move towards the inclusion of these topics in secondary mathematics classes for all students, even if it was in a more utilitarian mode meant to prepare students for military and civilian service.

Post-War Involvement

Once the country emerged from war, a Commission on Post-War Plans was appointed by NCTM in 1944 to tackle the deficiencies in mathematical preparation which had come to light during the war (CSMC, 2005). The Commission would publish a series of three reports over the next few years to address not only the incompetency problems encountered with soldier inductees but also those educational problems which had been put aside in order for the country to fight the war itself. In the first report published in May, 1944, proposals included ensuring mathematical literacy to all who could possibly achieve it and differentiating on the basis of student needs which were not being met by the traditional sequence of courses. A more applications-based approach utilizing real world scenarios was recommended for upper track courses such as Algebra, which prior to this were taught in the traditional theory-based college-prep style (CSMC, 2005). The second report in May, 1945, offered a series of theses covering grades 1-14. Grades seven and eight would be built around the categories of number and computation, geometry of everyday life, graphic representation, and elementary algebra. Ninth grade provided a double track in mathematics, splitting into those who were ready for more formal algebra and other who would continue in general mathematics, an option which is also used in present day schooling. A third report, named the *Guidance Report*, was published in November, 1947. This final report sought to inform and counsel students, administrators and parents on mathematics needed for career preparation (CSMC, 2005). Mathematical curriculum tracks in secondary school would depend on students' needs whether that be sequential mathematics to prepare for college, related and integrated mathematics topics to prepare for trade school, or social mathematics (e.g., mathematics used in daily life, such as budgeting) to prepare for general citizenship (CSMC, 2005).

Unfortunately the reports did little to move the reform agenda forward, in spite of the country being ready for change following the war. Progressive education, which favored usability rather than abstract conceptualism, continued as the norm until the 1950s. Secondary mathematics moved to serving the needs of all American students, including the 60% that were projected to attain employment as unskilled or semi-skilled workers following graduation. The Life Adjustment Movement (Klein, 2003) focused high school mathematics on consumer skills that everyone would need rather than algebra, trigonometry and geometry. However, by the end of the 1940s technological changes in society (i.e., electronics, navigation systems, atomic energy, and computers) could not be ignored as they became a more significant part of the national economy. Perhaps the critics (namely math educators and mathematicians) were right: students were going to need higher math to work in these fields. It was time to modernize mathematics.

The Rise and Fall of New Math

Enrollment in advanced high school mathematics courses decreased from 1933 to 1954 in spite of higher overall high school enrollment. Enrollment in Algebra I decreased from 56.9% in 1910 to just 24.8% in 1955 (Klein, 2003). College and universities complained that their students were taking fewer mathematics courses and were not well prepared for them (Woodward, 2004). Researchers took the view that preparation for higher level secondary courses needed to start before students got there, and so "new math" was born. Old math tended to be pragmatic and focused on tasks that students would need to perform in their future careers, whereas new math focused on mastery of fundamental concepts, some of them quite abstract (Vigdor, 2013). The New Math movement attempted to introduce more rigor and higher-order thinking skills to what was often a process of learning mathematics through mastering and practicing algorithms and formulas (Rasmussen et al., 2011).

The Soviet launch of *Sputnik* in 1957 highlighted a crisis in confidence of American mathematics and science education. Public perception was that we were losing the space race to the Soviets, which was unthinkable. There were few state frameworks in place, and neither national standards nor assessments existed. While providing public education is a state responsibility rather than a federal government power, the current international situation was considered a national threat to U.S. safety and pride. As such, the federal government responded with extensive federal funding for math and science programs, much like the recent funding increases in the past decade for STEM (science, technology, engineering, mathematics) programs in K-12 and higher education. The Commission on Mathematics College Entrance Examination Board published the CEEB report in 1959, highlighting suggestions for curricular change to facilitate the push to increased higher mathematics course achievement in high school. Prior to high school, most students had little or no exposure to algebra instruction. Algebra was viewed as the gateway course for students entering high school, as it laid the foundation for the logic and reasoning needed in higher level math classes. The CEEB report promoted going beyond the terminology and symbolism of traditional algebra to include concepts such as properties, inequalities and functions (CSMC, 2004). Deductive reasoning – usually reserved for a formal geometry class – would also be included in algebra. The Cambridge Conference on School Mathematics (CCSM) concurred and proposed teaching algebra beginning with seventh grade (CSMC, 2004) so that students could move on to topics such as topology, linear algebra, and calculus once they entered high school. This more modern take on mathematical content which would have students progressing far beyond the traditional high school curriculum was touted as an improvement over the stuffy, traditional mathematics coursework of old, and became known as New Math (CSMC, 2004).

The New Math movement focused on conceptual knowledge over basic skills, particularly at the elementary grades, a learning theory supported by the work of psychologists Jean Piaget and Jerome Bruner (Herrera & Owens, 2001). Piaget's theory of cognitive development combined with Bruner's promotion of student investigation and discovery to create a more child-centered curriculum than had ever been seen before. New Math attempted to introduce a formal understanding of mathematical principles and concepts from the early grades on (Woodward, 2004). Algebra was not just about the manipulation of symbols, and the onus was on educators to find a way to teach these more abstract concepts to a much younger audience.

Following many of the treatises laid out in the CEEB report, major universities were funded for large-scale curriculum development projects (Woodward, 2004).

Mathematicians worked alongside mathematics teachers on such projects as the University of Illinois Committee on School Mathematics (UIC-SM) and the School Mathematics Study Group (SMSG) created by the American Mathematical Society and funded by the newly established National Science Foundation (NSF) (Klein, 2003). The SMSG work was the most widely used, and the committee went on to write curriculum for grades kindergarten through twelfth. While considerable time was spent on writing the curriculum, almost no time was spent on actually experimenting to see if the curriculum was effective; however, by 1960 this new math curriculum was in use in most high schools, and by the end of the 1960s had filtered its way to the elementary grades as well. As seen today in current state standards and the Common Core, many mathematical concepts were pushed back into earlier grades. Coursework previously attended to in college (calculus for example) was now expected in high school.

All in all, New Math was a radical educational experiment that failed miserably, primarily due to poor implementation. The education community failed to test their products before going full-scale with them. Abstract mathematical concepts, alternative algorithms, and multiple base systems confounded parents, who complained that they weren't able to help their children with their school work. Students who were struggling with the more basic traditional curriculum did not excel with these new methods and the back-shifting of conceptual ideas to earlier grades, although no longitudinal studies were ever done to determine the movement's effect for students entering college (Kline, 1973). Teachers did not understand the curricular content or how to teach it effectively, perhaps because the majority of the curriculum was written by university professors who were revered more for their content knowledge than their pedagological skill with K-12 students. Even Richard Feynman, a prominent physicist who was also known as a great teacher, criticized New Math as being written by pure mathematicians who were not interested in the connections of mathematics with the real world, nor in the mathematics used in science and engineering (Feynman, 1965).

New Math failed to connect with both the general public and the professional scientific community it was developed to benefit. For secondary mathematics, it showed that simply moving a curriculum down from college to high school without any consideration for restructuring it to meet student needs was a form of curricular elitism which did not connect with most of the student population (Ellis & Berry, 2005). By the mid-1970s new math had fallen out of favor with the public as a whole. Morris Kline's 1973 book *Why Johnny Can't Add* suggests that the New Math movement was backlash of mathematicians against professional educators who were dominating educational policy. Kline reminds his readers that the purpose of K-12 education in America is to educate <u>all</u> students, not just those who would go to college to become mathematicians. It nothing else, the New Math movement raised the question again of *What mathematics is appropriate for whom?* (CSMC, 2004)

The Pendulum Swings

The Back-to-Basics movement of the 1970s was a backlash against the New Math reforms which preceded it. Compartmentalized, skills-oriented instruction became the focus for America's mathematics classrooms, with "skill and drill" emphasized over problem solving and creativity. States began using minimum competency testing, and while the Back-to-Basics movement did seem to improve test scores for lower performing students, those students were not being successful in higher math courses that required conceptual thinking (Ellis & Berry, 2005). Seeking middle ground that would prove effective, the country began to move towards a national mathematics curriculum.

In 1980, the National Council of Teachers of Mathematics (NCTM) published *An Agenda for Action: Recommendations for School Mathematics in the 1980s.* NCTM advocated for a change in the way mathematics was taught, moving towards a constructivist, problem-solving philosophy which took advantage of emerging technologies (e.g., calculators, graphing calculators, and computers). Their position that "difficulty with paper-and-pencil computation should not interfere with the learning of problem-solving strategies" (NCTM, 1980 Section 6.4) was a major shift in approach to teaching mathematics in using technology to open the curriculum to students who lacked some basic skills. NCTM also suggested a move away from the sequential course development path usually found in Algebra I, Geometry, Algebra II and trigonometry to a curriculum that would serve all students, not just those planning on attending college. As such, they de-emphasized the completion of calculus in high school, which today is an expected course for students going on to college and is often used as the impetus for starting high school mathematics in middle school. Although the suggestions made in this document heralded reforms that would occur in the future, NCTM's publication failed to capture the attention of the public at this time, and little change occurred.

Conversely, the publication of *A Nation at Risk* (1983) made headlines across the country. At the time of the report 35 out of 50 states required only one year of mathematics for graduation (National Commission on Excellence in Education, 1983). Remedial mathematics coursework at the college level had risen 72% over the five year span of 1975-1980 (Klein, 2003). The commission recommended increasing the number of courses required for high school graduation, including coursework that would prepare high school graduates to understand algebraic concepts needed for the study of computer science.

Scores on the Scholastic Aptitude Test (SAT) had steadily decreased since peaking in 1964, and scores on the National Assessment of Education Progress (NAEP) fared no better (Klein, 2003). Internationally the U.S. was falling behind other countries. U.S. political leaders called for change, and the National Research Council brought together the Mathematical Sciences Education Board, the Board on Mathematical Sciences, and the Committee on the Mathematical Sciences in the Year 2000 to conduct studies, resulting in *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (National Research Council, 1989). Current mathematics education filtered students out of programs leading to professional careers, and the Council called for fundamental changes in the entire teaching/learning system, not just the curriculum. It pointed to the fact that the American public tended to assume that differences in mathematics achievement are due to differences in innate ability, and that poor performance in mathematics had become socially acceptable." (NRC, 1989, p.10) Unlike the *Standards* that would follow, this report spoke more to process of teaching and promoting mathematics than the content. The report would help set in motion a public movement towards national standards so that preparedness for higher mathematics could more accurately be measured.

In 1986 NCTM had formed the Commission on Standards for School Mathematics. This commission was tasked with "creating a coherent vision of what it means to be mathematically literate in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly and growing and is extensively being applied to diverse fields." (NCTM, 1989, p.1). The result of this group's work was the *Curriculum and Evaluation Standards for School Mathematics* (1989) – also known as the *Standards* - which organized 54 standards by grade bands (K-4, 5-8, and 9-12) and processing areas (problem solving, communication and reasoning). This was the first move towards establishing national framework of expectations for school mathematics.

NCTM's *Standards* set in motion the change in mathematics education that the New Math era failed to produce. While called the *Standards,* they did not resemble what we currently expect from educational standards. Today's standards are set by the state and give specific skills to measure. They define what a teacher instructs in the classroom and are assessed at the state level with standardized testing. In contrast, NCTM's 1989 *Standards* provided a road plan for moving away from traditional mathematics teaching of the past towards a more constructivist approach which they advocated in 1980's *An Agenda for Action* and vehemently opposed during the progressivist movement of the 1920s. For the teaching of algebra, this meant a shift away from traditional problems usually seen in textbooks to a "real-world problem" approach not only in problems for students to solve but in the way the material was presented for learning.

NCTM encouraged calculator use at all grade levels, particularly the use of graphing calculators at the high school level. Grades K-4 would now include the new topic of "patterns and relationships" which laid a foundation for the study of functions in algebra. While Algebra was rarely taught at the middle school level, the Committee suggested moving beyond computations to include algebra, geometry, and probability and statistics in real-life applications to engage students' interest. Formal study of patterns and functions were added, and ratios and proportional reasoning should be mastered. Reasoning and symbolic representations – both important components of algebra – were to be stressed as well. Algebra in middle school had arrived.

Mathematics Equals Opportunity

By the mid-1980s, the debate on teaching Algebra I in middle schools had begun to heat up. Fernand Prevost's study of New Hampshire students in 1985 found that only half of students who took Algebra I as eighth graders continued to study mathematics through their senior year in high school (Prevost, 1988). He recommended enriching the current eighth grade curriculum rather than accelerating students into a high school mathematics course while still in middle school, an approach that NCTM also supported. Zalman Usiskin (1987), a prominent mathematics researcher at the University of Chicago, argued that Algebra I should be offered in eighth grade to average students as well as those deemed advanced in mathematics. Citing results from the Second International Mathematics Study (SIMS, 1982), Usiskin pointed to successful teaching of algebra to average students in the middle grades in Japan and Hong Kong, which had the highest scores on the SIMS. He also argued that we should not hold younger students to a higher standard to enroll in Algebra I than we do older students (Usiskin, 1987). Both Prevost and Usiskin made arguments regarding readiness for Algebra I as being the end result of mathematics learning in prior grades. Weak instruction and content mastery in earlier grades would prevent success in Algebra I which could in turn "turn off" a student to continuing in mathematics (Prevost, 1988; Usiskin, 1987).

It became apparent during this time period that even though equal education was guaranteed by federal law, it did not always play out that way in practice. Robert Moses, a civil rights activist in Mississippi during the 1960s, saw mathematics as a gate that was being firmly shut against minority students due to the educational paths offered them. Moses argued that access to college-level math depended on high school coursework, which in turn depended upon sufficient preparation in middle school mathematics and, in particular, access to Algebra I (Moses, 2001). Selective policies which restricted students from entering the track of Algebra I in eighth grade made it virtually impossible for students to complete calculus by the end of high school. Algebra I was not only an instructional concern but also an equity and civil rights issue (Stein et al, 2011).

Results from the National Assessment of Educational Progress (NAEP) also supported the need for mathematics equity. While NAEP scores in mathematics had improved from the early 1980s through the mid-1990s, the gap between high and low performing students widened, with the majority of low performing students being minority or low income students. (National Science Board, 2002). The Third International Mathematics and Science Study (TIMSS) showed U.S. eighth graders falling behind most Asian and European countries, with only 51% of U.S. students correctly answering algebra questions and 41% correctly answering proportionality questions (Beaton, et.al., 1996) Middle school mathematics was seen as the weak link in preparing students for higher level math in high school, as other countries focused on teaching Algebra I to students at the seventh and eighth grade level rather than waiting until high school (Beaton, et.al, 1996). The United States was poorly preparing its students to be successful in Algebra I and limiting general access to the course due to racial and socio-economic discrimination, which was causing the U.S. to fall behind other countries.

Realizing the gravity of the situation, Secretary of Education Richard Riley published *Mathematics Equals Opportunity* in 1996 which formally pushed the movement of Algebra I towards middle school. In 1992, only 20% of students took Algebra I in eighth grade, with less than 15% of minority or low income students doing so (Riley, 1996). Riley cited the need for rigorous high school mathematics preparation in order to enter college, particularly for "first generation" college students. He feared the United States would lose ground in a global economy if it could not produce qualified workers in an ever-increasing technology-based society. Riley deemed Algebra I the "gateway course to rigorous mathematics courses," a label which still exists today (Riley, 1996, p.5).

States began to move towards an eighth grade curriculum that included algebra, even for those students who were not formally enrolled in Algebra I (NCTM, 2000). NCTM had followed up the 1989 *Standards* with *Professional Standards for Teaching Mathematics* in 1991 and *Assessment Standards for School Mathematics* in 1992 which advocated a constructivist approach to teaching and assessing mathematics. Many states were adopting curricular frameworks that mirrored the NCTM standards, and in 2000 NCTM updated the *Standards* with a specific grade 6-8 band for content as well as processing standards (NCTM, 2000). The middle school grade band emphasized the integration of algebra and geometry concepts and advocated for students to have a strong foundation in algebra by the eighth grade (NCTM, 2000). While not technically advocating completion of Algebra I by the end of eighth grade, NCTM took the position that any student was ready should have access to the course at the middle school level and all students should complete an Algebra I course as a high school graduation requirement.

The Age of Accountability

No Child Left Behind (NCLB) changed the landscape of American education in 2001. States were now required to test students in reading and math each year in third through eighth grades, meeting mandatory benchmarks annually with the goal of having 100% of students in all subgroups proficient by 2014. Failing to meet benchmarks would result in sanctions and possible loss of local control of schools. States would develop their own curriculum frameworks and assessments to use in measuring proficiency. In addition, states would be required to participate in the NAEP every other year for grades 4 and 8, with a national sample at grade 12 added. (No Child Left Behind, 2003).

The late 1990s brought a move towards a universal algebra policy which provided Algebra I for all students in eighth and ninth grade regardless of prior achievement. Eighth grade enrollment in advanced math courses (Algebra I, Algebra II, Geometry) rose from 16% in 1990 to 27% in 2003 (NAEP, 2003). California recorded 40% of students taking Algebra I the eighth grade as it became the default math content standard for that grade level in order for the state to avoid non-compliance issues with No Child Left Behind. (Rosin, Barondless, & Leichty, 2009). Chicago Public Schools moved towards all students completing Algebra I by the end of ninth grade, providing longer blocks of time for teaching math in order to help lower performing students (Allensworth, et al., 2009). Charlotte-Mecklenburg Schools in North Carolina initiated a program that moved moderately-performing students taking Algebra I in eighth grade from less than half to nearly 90% (Clotfelter, Ladd & Vigdor, 2012). Washington, D.C., with some of the lowest mathematics scores in the nation on the NAEP, moved to placing all students in eighth grade Algebra I. Nationally the proportion of students taking Algebra I in eighth grade had doubled by 2007, (Perie, Moran & Lutkus, 2005; Walston & McCarroll, 2010) and California, Maryland, Utah and the District of Columbia exceeded 50% of students enrolled in Algebra I in middle school (Loveless, 2008).

As more students nationwide moved into Algebra I in middle school, NCTM released the *Curriculum Focal* Points in 2006 to identify key concepts to be learned at each grade level. Algebra as a strand appears as early as Grade 2, and the Grade 8 focus included analyzing and representing linear functions and solving linear equations and systems of linear equations (NCTM, 2006), components normally found in an Algebra I course. While not formally advocating an algebra-for-all in eighth grade policy, NCTM did promote more overlap between concepts taught in Algebra I and Grade 8 mathematics, presumably to help better prepare students for the formal course. States such as Minnesota followed this lead by introducing more algebraic concepts in eighth grade mathematics that would continue into Algebra I, effectively creating a "bridge" class between middle school and high school mathematics, with students receiving no high school credit until ninth grade (MCTM Algebra Task Force, 2007).

Fourth grade scores on the NAEP improved steadily from 1995 to 2008, but eighth grade scores did not show the same improvement rate and twelfth grade scores were stagnant. Only 39% of eighth grade students scored at or above the proficient level in 2008 (U.S. Department of Education, 2007), a figure which dropped to 23% by 12th grade (U.S. Department of Education 2005). In spite of the requirement of state standards and accountability and more students enrolling in secondary mathematics at an earlier age, U.S. students were not performing in mathematics at the level expected of an international leader. President Bush established a National Mathematics Advisory Panel with the emphasis to determine how to prepare students for success in Algebra I (NMAP, 2008a, p.xv). The Panel set forth the major topics of Algebra I and Algebra II and recommended that all prepared students have access to an "authentic" course which included these topics by Grade 8 (NMAP, 2008a, p.xviii). These mathematical topics will be discussed in detail in Section II of the Literature Review.

A Move Towards National Standards

Following the National Math Panel Report, many states were looking at a need to critically revise their standards to be in alignment with the recommendations given. National standards had been brought up and dismissed several times in the previous century, but now that most states had already made the hurdle to establishing state curriculum standards, the move towards a national curriculum did not seem as outlandish. Most other countries who participated in the TIMSS study had national curriculum set forth, particularly for eighth grade mathematics (Cogan, Schmidt, & Wiley, 2001). The United States' lack of a coherent curriculum with a common vision was hurting its performance on international assessments (Cogan, Schmidt, & Wiley, 2001).

The movement towards a national curriculum began not in the U.S. Department of Education but by the nation's governors and education commissioners. The National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO), together with input from teachers, school administrators, and parents, began to develop what is now known as the Common Core State Standards (CCSS). The standards set forth a single set of standards for grades kindergarten through twelve in mathematics and English language arts. (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The goal of the CCSS is to best prepare high school graduates to enter the workforce or a two-year or four-year college program. States are able to opt in or out of the standards, with 45 states choosing to adopt the Common Core. Virginia, Texas, Alaska, Nebraska, and Minnesota chose not to adopt the CCSS-M (NGA & CCSSO, 2010) and will continue to assess students using their own state-developed tests. States that adopted the CCSS-M will begin to use common assessments developed in conjunction with the CCSS-M in 2014-15.While not an official adopter of Common Core, Virginia is recognized as having high standards by the American Federation of Teachers (AFT, 2008) which has translated into high scores for eighth grade students on the NAEP, with only five other states out-scoring Virginia (NCES, 2013). Specifics regarding Virginia's standards and assessments will be discussed in a later section of this literature review.

The Common Core State Standards – Mathematics (CCSS-M) offers specific curriculum for grades K-8, but diverts to strands (Number and Quantity, Algebra, Functions, Modeling, Geometry, Statistics & Probability) at the high school level (NGA & CCSSO, 2010). In light of this approach, some states are considering moving towards an integrated course structure in high school rather than the discrete content courses that currently prevail in the traditional pathway. New York already follows this policy, but some states (for example, North Carolina and Ohio) welcome the change from the traditional route, referring to the blurred lines that already exist between higher level mathematics strands when they are used in industry. Indiana and other states have chosen to allow school districts to choose between traditional and integrated curriculums

(Indiana Department of Education, 2013). It is unknown how this will affect eighth grade enrollment in mathematics, as for many students Algebra I as a formal course will no longer be an option. The CCCSS-M eighth grade curriculum is heavy in Algebra I topics, yet not a comprehensive Algebra I course. Having been considered the gateway course to higher math for over a century, it is uncertain if Algebra I will continue to no hold that title if a move to integrated mathematics takes place.

By 2011, 47% of eighth graders in the U.S. were taking Algebra I (NCES, 2012), yet the research remains unclear on whether or not this is the best route for U.S. students. The next sections will look at the pre-requisite content and processing skills needed for success in Algebra I and the current literature on how eighth grade students are fairing in this class.

The Study of Algebra

Mathematics is generally viewed as something you do, that requires action and thinking by the participant (Lee, 1997). It is a combination of content knowledge and processing skills which allow for the modeling of real-life scenarios using symbolic representation. Algebra makes the leap from pure arithmetic to a generalization of an arithmetic process (Smith, 2003). A simple definition of traditional school algebra is that it is the learning of rules for manipulating symbols (Smith, 2003), yet research has shown that learning algebra using a skills-based approach – such as memorizing a set of rules – does not translate to understanding or proficiency in algebra (Usiskin, 1987).

This section will examine algebra as a strand of mathematical knowledge and the content included in Algebra I as a formal course of study. It will also explore the content and processing skills necessary for success in an Algebra I class as well as brain-based research on when these abstract concepts can be learned.

The use of algebra with a lower-case "a" refers to the mathematical strand. The term Algebra with a capital "A" refers to a formal high school, credit-bearing course. In most cases this will be followed by the Roman numeral "I" to indicate the beginning course in formal Algebra study.

Algebra as a Strand of Mathematical Knowledge

So what exactly is algebra? Lee (1997) posed the question "What is algebra?" to a cohort of mathematicians, teachers, students and mathematics education researchers. Their responses included a school subject, a tool, generalized arithmetic, a language, a way of thinking, and an activity. Algebra is alternately viewed as algebra (the subject), algebraic thinking (the method), or algebraic language (the visual result) (Kieran, 2007). Algebra is an application and extension of previously learned arithmetic principles which can be used to model generalized situations. In the simplest sense, algebra is universalized arithmetic (Kaput, 2000).

As a strand of mathematics, algebra includes the study of variables and expressions; equations and inequalities; patterns, relations, and functions; coordinate geometry; and trigonometric functions (NYSDE, 2005). Prior to the 1990s, students were expected to learn arithmetic first then progress to algebra (Carraher & Schliemann, 2007). This traditional pathway in mathematics was rarely questioned by either teachers or students, and students were expected to arrive in high school ready to make the leap in abstract thinking from arithmetic to algebra. Once in high school, students enrolled in Algebra I, a formal course of study that focused only on the algebra strand of mathematics.

As mathematics education moved towards a more progressivist approach in the late 1980s, NCTM's *Principles and Standards* recommended that algebra be woven as a mathematical strand throughout the K-12 curriculum (NCTM, 1989; 2000). Rather than waiting until middle school or high school, teachers in the elementary grades would expose students to such algebraic concepts as field axioms (i.e., properties), symbolic representation, and the concept of equivalency. Kindergarteners learning to identify patterns with shapes and colors are laying the base knowledge for the development of functions and sequences in mathematics. Students in elementary school translating a word or story problem into an arithmetic equation are modeling a concrete situation, which is a precursor to writing equations that utilize a variable to represent an unknown quantity. Middle school students learning integer operations and proportional reasoning continue to build upon their knowledge of equivalency (NCTM, 1989). The strand of algebra became a unifying concept woven throughout the K-8 mathematics curriculum, which better prepared students to move to the more abstract and formal Algebra I found at the high school level (NCTM, 2000).

Algebra I as a Formal Course of Study

Traditional Algebra I was taught as a set of procedures disconnected from other mathematical knowledge and students' real world experiences, to the point that even students who enjoyed math began to dislike the subject (Kaput, 2000). Considered the gateway course to higher mathematics, Algebra I has served to bar many students from entry in those other classes, and therefore the careers that would result from taking them.

According to the National Council of Teachers of Mathematics (NCTM), algebra encompasses the relationships among quantities, the use of symbols, the modeling of phenomena, and the mathematical study of change (NCTM, 2000). With the standards movement underway, a formal attempt to define the content of Algebra for high school came about in NCTM's *Principles and Standards* (NCTM, 2000, p296) as seen in Figure 1 below:

Figure 1

Algebra Standards for Grades 9-12

Algebra Standards for Grades 9-12
(NCTM *Principles and Standards*, 2000, p.296)

Understand patterns, relations, and functions

- Understand algebraic properties for expressions, equations, and inequalities and manipulate them by hand or using technology.
- Utilize functions for mathematical modeling.
- Understand relations and functions and use various representations. Interpret representations of functions of two variables.

Represent and analyze mathematical situations and structures using algebraic symbols

- Understand the meaning of equivalent forms of expressions, equations, inequalities and relations.
- Write and solve with fluency equations, inequalities and systems of equations.
- Use symbolic algebra to represent and explain mathematical relationships.

Use mathematical models to represent and understand quantitative relationships

- Identify quantitative relationships in a situation and determine the type of function that might model the relationships.
- Use symbolic expressions to represent relationships.
- Draw reasonable conclusions about a situation being modeled.

Analyze change in various contexts

- Approximate and interpret rates of change from graphical and numerical data.

NCTM's standards present Algebra content in a somewhat esoteric fashion, speaking more to the mathematics education professor than to the classroom teacher. While *Curriculum Focal Points* in 1996 clarified the content of pre-kindergarten through eighth grade mathematics, it did not delve into high school content at all.

The next attempt to clarify Algebra topics would occur with the National Mathematics Advisory Panel's (NMAP) report published in 2008. Using the Third International Mathematics and Science Study (TIMSS), U.S. state standards specifying Algebra I and Algebra II courses, and Singapore's mathematics curriculum for grades 7 - 10, the Panel recommendations focus on the Algebra topics most frequently seen in all three sources (NMAP, 2008).

As seen in Figure 2, the NMAP report gives a much more coherent definition aimed at practitioners by listing topics rather than broader learning goals.

Figure 2

The Major Topics of School Algebra

The Major Topics of School Algebra
(National Mathematics Advisory Panel, 2008, p.16)

<u>Symbols and Expressions</u>

- Polynomial expressions
- Rational expressions
- Arithmetic and finite geometric series

<u>Linear equations</u>

- Real numbers as points on the number line
- Linear equations and their graphs
- Solving problems with linear equations
- Linear inequalities and their graphs
- Graphing and solving systems of simultaneous linear equations

<u>Quadratic Equations</u>

- Factors and factoring of quadratic polynomials with integer coefficients
- Completing the square in quadratic expressions
- Quadratic formula and factoring of general quadratic polynomials
- Using the quadratic formula to solve equations

<u>Functions</u>

- Linear functions
- Quadratic functions – word problems involving quadratic functions
- Graphs of quadratic functions and completing the square
- Polynomial functions (including graphs of basic functions0
- Simple nonlinear functions (e.g., square and cube root functions; absolute value; rational functions; step functions)
- Rational exponents, radical expressions, and exponential functions
- Logarithmic functions
- Trigonometric functions
- Fitting simple mathematical models to data

<u>Algebra of polynomials</u>

- Roots and factorization of polynomials
- Complex numbers and operations
- Fundamental theorem of algebra
- Binomial coefficients (and Pascal's Triangle)
- Mathematical induction and the binomial theorem

<u>Combinatorics and Finite Probability</u>

- Combinations and permutations, as applications of the binomial theorem and Pascal's Triangle

Some states looked to the NMAP's recommendations when revising their state standards. Already on the horizon, however, was the Common Core State Standards – Mathematics (CCSS-M) which the majority of states have chosen to embrace and adopt rather than re-writing and updating their existing state standards. Developed by the National Governors Association (NGA) and the Council of Chief State School Officers (CCSS), the Common Core standards aim to prepare all students graduating from high school with the skills they need to be successful whether entering the workforce of a two or four year college program (NGA & CCSSO, 2010). Figure 3 shows the major themes and topics included for high school Algebra as determined by the Common Core Standards.

Figure 3

High School Algebra (CCSS-M)

High School: Algebra (Common Core State Standards – Mathematics, 2010)
• **Seeing Structure in Expressions** o Interpret the structure of expressions o Write expressions in equivalent forms to solve problems • **Arithmetic with Polynomials and Rational Functions** o Perform arithmetic operations on polynomials o Understand the relationship between zeros and factors of polynomials o Use polynomial identities to solve problems o Rewrite rational functions • **Creating Equations** o Create equations that describe numbers or relationships • **Reasoning with Equations and Inequalities** o Understand solving equations as a process of reasoning and explain the reasoning o Solve equations and inequalities in one variable o Solve systems of equations o Represent and solve equations and inequalities graphically

Note. Adapted from *Common core state standards – mathematics (CCSS-M)* by the National Governors Association Center for Best Practices, Council of Chief State School Officers (NGAC, CCSS) (2010).

There is coherency among the NCTM, NMAP and CCSS-M content recommendations for Algebra in spite of the differences in how the content is communicated (i.e., readability). While NCTM and NMAP include functions and the real number system as part of their prescribed Algebra coursework, CCSS-M lists both of these topics in separate domains -- Functions, and Number and Quantity (NGAC & CCSSO, 2010). None of the three entities dictates whether these concepts should be learned in the customary sequence of year-long classes (Algebra I, Geometry, Algebra II, Pre-calculus) or as part of an integrated curriculum (Mathematics 1, Mathematics 2, Mathematics 3) (NMAP, 2008) as state and local school divisions have the right to decide curriculum sequencing.

Pre-requisite Content Skills Needed for Algebra I

Educational authority rests with state and local governing bodies. As such, there have been differences in which pre-requisite content and skills are considered necessary before a student embarks on an Algebra I class as state and local school divisions determine the curriculum and sequencing of mathematics content. While NCTM recommended threading algebraic concepts throughout the K-12 curriculum (NCTM, 1989), there was no requirement by states to do so. This resulted in some states continuing with an arithmetic-based curriculum through middle school while others used NCTM's recommendations to revise their state standards. An analysis of U.S. mathematics curriculum versus that of other top-performing countries (i.e., Singapore, Japan, Finland) showed that United States mathematics curriculum was over-reaching and shallow compared to other countries, and that the mathematics curriculum varied dramatically from state to state in sequencing, rigor, and inclusion of topics (NCTM, 2006).

NCTM decided to clarified portions of its *Principles and Standards* in 2006 with the publication of *Curriculum Focal Points,* which broke down by grade level the essential skills and topics to be learned at each grade level. Figure 4 shows the expected knowledge for the algebra strand by the end of middle school, at which point students would be expected to progress to an Algebra I course in high school.

Figure 4

NCTM's Expectations for Knowledge in the Algebra Strand

NCTM's Expectations for Knowledge in the Algebra Strand Grades 6-8	
	Grade Level
Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and when possible, symbolic rules	6, 7, 8
Relate and compare different forms of representation for a relationship	7
Identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations	7, 8
Develop an initial conceptual understanding of different uses of variables	6, 7, 8
Explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope	8
Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships	6, 7, 8
Recognize and generate equivalent forms for simple algebraic expressions and solve linear equations	6, 7, 8
Model and solve contextualized problems using various representations, such as graphs, tables, and equations	6, 7, 8
Use graphs to analyze the nature of changes in quantities in linear relationships	8

Note. Adapted from *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence* (NCTM, 2006, pg 36-37)

The National Mathematics Advisory Panel (NMAP) was created to focus on how to better prepare U.S. students to take Algebra in eighth grade. In particular, the Conceptual Knowledge and Skills Task Group (NMAP, 2008) determined the major topics of Algebra (as seen in Figure 5). This committee looked at top-performing countries and states to identify essential math concepts and skills that should be learned in preparation for Algebra (NMAP, 2008). Of particular note was that international curriculum focused on far fewer topics at much greater depth than did the U.S. curriculum and mastery was expected before moving to another topics rather than a continual spiraling used in U.S. curriculum (Schmidt, Houang, & Cogan, 2002). The top six countries in the TIMSS study (Singapore, Japan, Korea, Hong Kong, Flemish Belgium, and the Czech Republic) all taught Algebra in the eighth grade, if not sooner (NMAP, 2008). Grades 1-4 were primarily arithmetic-based, followed by two transition years (Grades 5-6) where students learned proportionality and coordinate geometry, until reaching Algebra and Geometry in Grades 7 and 8 (Schmidt, Houang, & Cogan, 2002).

A comparison of NCTM's *Curriculum Focal Points* with top-achieving TIMSS countries (Schmidt & Houang, 2007) found that students in the early grades would study many more topics under NCTM's guidelines than do students in other countries (NMAP, 2008, p.3-35). In particular, NCTM's recommendation of threading algebraic concepts through K-8 leading up to study of Algebra did not match at all with international curriculum, which does not introduce Patterns, Relations and Functions until the eighth grade (NMAP, 2008, p.3-35).

Klein et al. (2005) identified the six highest-rated state curriculums (California, Indiana, Massachusetts, Alabama, New Mexico, and Georgia). The Panel's comparison of common topics and their introduction for these states compared to TIMSS countries once again showed that primary grades in the U.S. spend a considerable amount of time on topics other than arithmetic, such as probability and data analysis, and U.S. students were exposed to far more geometry and algebra content in the early grades than international students (NMAP, 2000, p3-38).

In keeping with the "less is more" mindset of top-performing international countries, the Panel developed the Critical Foundations for Success in Algebra seen in Figure 5 below, as well as benchmarks for concept proficiency.

Figure 5

Critical Foundations for Success in Algebra

Critical Foundations for Success in Algebra (National Mathematics Advisory Panel, 2008, p.3-42)	
	Benchmarked grade level
Fluency with Whole Numbers	
• Addition and subtraction of whole numbers	3
• Multiplication and division of whole numbers	5
Fluency with Fractions	
• Identify and represent fractions and decimals, compare them on a number line or with other common representations of fractions and decimals	4
• Compare fractions and decimals and common percents	5
• Add and subtract fractions and decimals	5
• Multiply and divide fractions and decimals	6
• Integer operations	6
• Operations with positive and negative fractions	7
• Solve problems involving percent, ratio, and rate and extend this work to proportionality	7
Particular Aspects of Geometry and Measurement	
• Solve problems involving perimeter and area of triangles of all quadrilaterals having at least one pair of parallel sides (i.e., trapezoids)	5
• Analyze the properties of two-dimensional shapes and solve problems involving perimeter and area	6
• Analyze the properties of three-dimensional shapes and solve problems involving surface area and volume	6
• Be familiar with the relationship between similar triangles and the concept of the slope of a line	7

While differences exist between NCTM and NMAP, one topic they do agree is critical to success in higher math is fractions. A 2012 study by Siegler showed that a student's knowledge of fractions by the end of fifth grade can predict performance in high-school mathematics even after controlling for variables such as IQ, reading achievement, working memory, and socio-economic status (Shellenbarger, 2013). Lacking understanding of fractions makes it impossible for students to understand algebra, geometry, physics, statistics or chemistry (Shellenbarger, 2013, p. D1). The National Mathematics Advisory Panel identified mastery of fractions, including comparisons and operations, as a critical skill to success in Algebra (NMAP, 2008a). Their survey of Algebra teachers found that poor preparation in rational numbers and operations involving fractions were the weakest areas for students coming into Algebra I (NMAP, 2008b, p.9-7). Based on their recommendations, the Common Core standards adopted by most states is organized so that students complete mastery of fractional operations by the end of fifth grade in order to better prepare them for Algebra (NGAC & CCSSO, 2010)

Processing Skills Needed for Algebra I

To prepare students for Algebra, the curriculum must simultaneously develop conceptual understanding, computational fluency, and problem-solving skills. These three concepts are at the same level of importance and deserve equal time in the classroom (NMAP, 2008, p3-40). In addition to content standards, mathematical learning also includes these process standards (NCTM, 2000). Process standards are the same for grades K-12 with the expected cognitive level increasing as the grade level increases. NCTM recognizes five distinct processing standards, as seen in Figure 6 below.

Figure 6

NCTM Processing Standards

<table>
<tr>
<td>NCTM Processing Standards

Adapted from
Principles and Standards 2000</td>
<td><u>Communication</u>
(NCTM, 2000, p.348)
Organize and consolidate their mathematical thinking through communication
Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
Analyze and evaluate the mathematical thinking and strategies of others
Use the language of mathematics to express mathematical ideas precisely</td>
</tr>
<tr>
<td><u>Problem Solving</u>
(NCTM, 2000, p.334)
Build new mathematical knowledge through problem solving
Solve problems that arise in mathematics and in other contexts
Apply and adapt a variety of appropriate strategies to solve problems
Monitor and reflect on the process of mathematical problem solving</td>
<td><u>Reasoning and Proof</u>
(NCTM, 2000, p.342)
Recognize reasoning and proof as fundamental aspects of mathematics
Make and investigate mathematical conjectures
Develop and evaluate mathematical arguments and proofs
Select and use various types of reasoning and methods of proof</td>
</tr>
<tr>
<td><u>Connections</u>
(NCTM, 2000, p.354)
Recognize and see connections among mathematical ideas
Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
Recognize and apply mathematics in contexts outside of mathematics</td>
<td><u>Representation</u>
(NCTM, 2000, p. 360)
Create and use representations to organize record and communicate mathematical ideas
Select, apply and translate among mathematical representations to solve problems
Use representations to model and interpret physical, social and mathematical phenomena</td>
</tr>
</table>

The Common Core State Standards – Mathematics (CCSS-M) follow the lead of NCTM in declaring Standards for Mathematical Practice (NGAC & CCSSO, 2010) which are also expected for grades K-12. The goal of these standards are to develop mathematically proficient students, starting with a basic level in the primary grades and progressing to higher order thinking in the middle and high school grades. Therefore, the practice standards seen in Figure 7 below apply to grades K-12 at the appropriate ability level of each grade.

Figure 7

Standards for Mathematical Practice (CCSS-M)

Standards for Mathematical Practice Common Core State Standards – Mathematics	
MP1: Make sense of problems and persevere in solving them	MP2: Reason abstractly and quantitatively
MP3: Construct viable arguments and critique the reasoning of others	MP4: Model with mathematics
MP5: Use appropriate tools strategically	MP6: Attend to precision
MP7: Look for and make use of structure	MP8: Look for and express regularity in repeated reasoning.

Note. Adapted from *Common Core State Standards – Mathematics* by the National Governors Association Center for Best Practices, Council of Chief State School Officers (2010).

In both cases, process/practice standards are used to develop conceptual understanding rather than simply learning mathematical procedures (NGAC & CCSSO, 2010). CCSS-M goes beyond NCTM's vision by including a practice standard addressing the appropriate use of tools. Prior to Algebra I many students use a basic scientific calculator for math calculations. In Algebra I they must become proficient with a graphing calculator which is considerably more sophisticated, requiring the use of function and secondary keys to not only enter numerical data but also to program the calculator to perform a specified task. While not specifically addressed in course content for Algebra I, developing facility with the graphing calculator is essential to success in future high school math courses. While procedures needed to utilize the calculator must be learned, students can use this tool to deepen and extend their understanding of a concept (NGAC & CCSSO, 2010).

The Common Core practice standards also include "attending to precision" (NGAC & CCSS, 2010, p. MP6) critical component of moving to higher math. Learning Algebra I and higher math requires facility with multi-step processes and multiple representations. As the mathematical equations, inequalities, and functions become more complex, students must work precisely to avoid errors which affect the solution. The move from concrete to abstract thinking is not simply a matter of presenting and learning more complex material – brain development plays a role as well.

Cognitive variability – using multiple thinking strategies when solving problems of the same type – is a spontaneous feature of children's thinking (Siegler, 2003). Yet even when students master strategies that are faster and more accurate, they continue to use older strategies that are slower and less accurate as well. These immature strategies will eventually drop away when they have enough knowledge to answer accurately without them. For students taking Algebra I a year early, the question could be if they have had enough time to develop that knowledge, particularly in regards to solving equations and proportional reasoning. If not, difficulties often arise in the form of incorrect extensions of correct rules and distorted versions of rules (Siegler, 2003).

In order to solve the multi-step problems found in Algebra I and beyond, working memory capacity needs to be higher to handle the combination of recalling previously-learned information and reasoning through the problem itself. Gathercole et al. (2003) found that for 14 year olds, there is a strong link between mathematics ability and working memory. General-purpose workspace provided by working memory is necessary to support the cognitive demands of processing and storage required in mathematical problems requiring multiple computations (Gathercole et al., 2003). Working memory capacity limits mathematical performance, but practice can overcome this limitation by achieving automaticity which is developed using practice distributed across time (NMAP, 2008, p4-5). Working memory limitations also make the processing of relational sentences in word problems and the discrimination of relevant form irrelevant information especially difficult (Cooney & Swanson, 1990).

The processing of algebraic expressions also differs from arithmetic computations. Students have to move from the traditional "up and down" processing used in arithmetic problems in elementary school to horizontal "left to right" processing used in algebra. Algebra contains an underlying syntax of implicit rules that guide the processing of expressions (NMAP, 2008, p.4-75). Learning of algebraic syntax is determined, in part, by earlier learned arithmetic rules, such as order of operations; use of the commutative, associative, and distributive properties; and by knowing the mathematical meaning of symbols, such as parentheses or summation signs, that note sub-expressions within the equation. Students must be cerebrally mature enough to combine numerical and variable components of equations and systems.

To solve equations and inequalities, students must have a full understanding of the concept of mathematical equality, particularly in regards to using the equal (=) sign (Knuth et al, 2006). Students must have progressed beyond an operational understanding of equal (in which the = sign means that the result or answer follows) to a relational understanding in which two or more quantities are determined to be equivalent but not necessarily the same (e.g., an equations such as $3(x - 4) = 2(x + 5)$.) Failure to move beyond the operational review can hinder the learning of algebra (Knuth et al, 2006).

Research has shown that early adolescence brings improvement in deductive reasoning and information processing (efficiency and capacity) which leads to greater capability in abstract, multi-dimensional thinking (Steinberg, 2005). It is common knowledge that children develop at different rates and not necessarily at a single defining age. Does beginning the formal study of the abstract concepts found in Algebra I a year earlier truly make a difference?

Arriving at Algebra I by Eighth Grade

Mathematics is by its nature sequential. One cannot do calculus unless you know the algebra needed to complete the problem; and one cannot do algebra unless you know the arithmetic needed to complete a solution. A review of the content topics in the previous section shows the need for abstract thinking and reasoning in order to understand and use algebra at the Algebra I level. As discussed in the first section of this literature review, almost half of U.S. students are currently taking Algebra I in the eighth grade, and that trend is expected to continue. In this section we will look at the mechanisms used by school divisions to get students into Algebra by eighth grade.

Curricular Pathways: The Track to Your Future

At some point in their education, the majority of students will be put on an academic track, particularly in mathematics (Loveless, 2013). Tracking is the practice of assembling students of roughly equal ability together in classes. This begins at the elementary school level in the form of leveling, as students are grouped by ability for reading within a class. As a student progresses through school, educational expectations tend to be set by parents, teachers, and administration. By the middle school grades, students attend different classes for each subject, so the within-class ability grouping used at the elementary school now becomes tracks determined by teacher and class placements. This results in an ever smaller and restricted slate of courses. Middle school science classes are very rarely leveled by ability groups and course tracks that would enable students to take high school science courses in middle school are rarely found (Hoffer, 1992). In general, reading and social studies courses in middle school continue to use a leveled approach. For example, students all take English 8, but some may be in a regular class and others in honors or gifted courses. Regardless, all these students will take the same end-of-year state assessment.

Compared to elementary and high school, tracking may have its firmest group in middle school – a constricting of the curriculum which then opens up somewhat in high school (Mulkey, et al., 2005). While other subject areas do not track at all (science) or continue to use leveling (reading and social studies), middle school mathematics tracking is the provision of substantively different mathematics content or curriculum to different students at the same grade level (Schmidt, 2009). This is not the same as ability grouping where the pace and depth of instruction may differ but the topics are consistent across levels. Rather than studying the same subject and thereby taking the same state assessments, students are now placed into classes which may vary not only in cognitive ability level (e.g., pacing and rigor) but also in content (e.g., pre-algebra versus Algebra I).

Mathematics tracking is commonly practiced in the eighth grade (Cogan, Schmidt & Wiley, 2001; Hoffer, 1992) as this is the final year before students typically enter the high school curriculum. Eighth grade tracking has two main effects: positional advantages and differential achievement growth (Schmidt, 2009, p7). Students who complete Algebra I in eighth grade position themselves to go further in mathematics in high school (Loveless, 2008). For minority and low income students, taking Algebra I in eighth grade lessens the likelihood of being placed into low-performing mathematics classes in high school, where curriculum tracking tends to adversely impact students in low level courses compared to high track ones and exacerbate achievement inequalities (Michigan State University, 2008).

Proponents of using tracking assert that by placing students at the same ability level together, teachers can match instruction to student capacities more effectively than in the non-grouped, heterogeneous context (Slavin, 1993). This technical view of learning and instruction seeks to maximize optimal outcomes through efficiency. Opponents of tracking make valid claims that while the theory of tracking sounds beneficial, in reality students are tracked for reasons far removed from their academic abilities (Spielhagen, 2008; Mulkey, Catsambis, Steelman, & Crain, 2005).

Tracking was commonly used in schools up until the 1990s, when it suffered a backlash due to research showing that equity issues severely undermined student' educational opportunities (Mulkey, et al., 2005). In spite of this movement, tracking continues to exist, especially in middle school mathematics.

Getting On Track: Placement Criteria

Tracking differentiates content exposure, which in turn can expand or limit one's educational opportunities not only in high school but in post-secondary plans as well (Ma, 2000). Much of the research on tracking is for math, as the criteria tend to be less subjective than other subjects due to the sequential nature of mathematics (Mulkey, et al., 2005). Yet even though we know that children develop at different rates, tracking is very rigid. Once placement is decided on there is little room for movement between tracks (Lucas, 2001).

Tracking is dependent on school policy, yet rarely is the practice of tracking made overt by administration (Michigan State University, 2008). Usually there is a division-wide policy in place with placement criteria stated which serves as a guideline for selecting students to various math pathways. Examples of criteria include the use of standardized test scores, class grades, diagnostic tests, parental input, and teacher recommendations. Useem (1992) found that math placement is highly dependent on standardized tests, teacher impressions and even parental contacts and power. Tracking placement is often seen as a social status marker, particularly by parents and even other teachers and students (Mulkey, et al., 2005).

The problem with most placement criteria is that they tend to be highly subjective, particularly as it relates to race and socio-economic status (Hoffer, 1992). Standardized test scores are the least subjective measure, yet rarely are they used as the sole measure for placement. Class grades are assigned using a combination of cognitive skills (typically assessed by test scores) and non-cognitive skills (e.g., judgments of effort) and can vary from teacher to teacher depending on the difficulty of assessments and grading policies (Pattison, Grodsky, & Muller, 2013). Parental input is often in the form of teacher or class requests, which may be based on social rather than educational goals (Useem, 1991). Particularly in schools with a high-socioeconomic base, administrators routinely accept parents' requests for mathematics placement (Spielhagen, 2006; Useem, 1991).

Teacher recommendations are often based not only on the grade a student earned in a class but also on the child's behavior and effort (Spielhagen, 2006). Behaviors other than math performance – maturity in behavior, verbosity, organization -- strongly influence a teacher's recommendation of a student for Algebra I, which as a high school course moves at a faster pace and with increased rigor compared to previous mathematics classes. Students who don't consistently produce high results, often true of students with IEPs, are unlikely to receive recommendations. (Faulkner, Crossland, & Stiff, 2013). Even when their math performance was equal to that of non-IEP students, students with IEPs were found to have one fifth the chance of placement into Algebra compared to their non-IEP peers (Faulkner, Crossland, & Stiff, 2013). And students who were strong in mathematics at the end of elementary school may still have not reached Algebra I in eighth grade, especially if the student is male or black (Walston, 2010).

Another problem arises when placements are made by personnel who are not well-versed in the subject matter. Research by Stiff, Johnson and Akos (2011) found that school counselors used free or reduced lunch status as academic data when placing students. When lacking any academic data, they fell back on race, thereby completely bypassing any logical academic considerations for placement (Stiff, Johnson, & Akos, 2011). In a study of an urban school district among students who demonstrated academic ability only 51% of blacks and 42% of Latinos were admitted whereas 100% of Asians and 88% of whites were placed into Algebra I (Stone, 1998).

Some school districts have moved to an algebra-for-all policy. This policy may take the form of requiring students to enroll in Algebra I as an eighth grader (e.g., California, Charlotte-Mecklenburg school district), or it might allow students to self-select into an Algebra I course in eighth grade regardless of prior achievement in mathematics. The TIMSS study of 50 countries showed that an algebra-for-all policy is used throughout most of the world (Schmidt, 2009).

Schmidt's comparison of tracked and non-tracked schools found that content rigor is about one half year higher in tracked schools offering Algebra I than in non-tracked schools, yet curricular content is a major contributor to differences in achievement across the tracks (Schmidt, 2009).

In an increasingly mobile society, there is also the consideration of students who move into a school district either from another town in the same state or from another state altogether. Students who have a non-routine change of school also have to cope with adapting to the localized sequence of courses and may become victims of ability grouping and be weakened by this (i.e., new school does not offer advanced courses).

Different Paths, Same Destination

In order to take Algebra I by the eighth grade, students must progress more quickly through the intended mathematics curriculum in a process known as acceleration. School divisions accomplish this by either compressing the curriculum or skipping some of the grade-specified content. There may be only one or various entry points to a particular pathway, and there may or may not be options if a student is not performing well in a particular course pathway. That may result in the student entering onto a different curricular pathway, or perhaps changing levels on the same pathway. At some point in their education, the majority of students will be put on an academic track, particularly in mathematics (Loveless, 2013). There are three main mechanisms which cause tracking effects: social, institutional, and instructional (Mulkey, Catsambis, Steelman, & Crain, 2005). While all hold importance, this study will be focusing on the instructional mechanism, which is defined as the level of demand or rigor of the content coverage for a course. The instructional pathways students enter in middle school are more rigid than those found in high school (Hoffer, 1992) when students encounter more course choices. Therefore, when and what pathway a student is on can profoundly affect not only his/her middle school mathematics exposure but also what will be encountered in high school.

States and/or school divisions prescribe curriculum sequences in high school which correlate to students' graduation plans: four year college, community college, career training, or directly entering the work force. Originally these tracks were spread across all subjects, whereas now they are subject-specific. While the curriculum pathways become more overt at the high school level, many students have entered their track by middle school or even late elementary school (Stiff, Johnson & Akos, 2011). While available tracks may vary by school, the hierarchical nature of mathematics tends to result in similar course sequences across the U.S. (Stevenson et al, 1994). Most schools use two to three tracks for students at the seventh and eighth grade levels in mathematics, but this is very dependent upon school size (Hoffer, 1992). Therefore in order to take a first-year high school course in eighth grade, students must somehow move ahead in mathematics by the equivalent of one academic year. Most school divisions accomplish this acceleration through compressing the curriculum or skipping content.

Compressing the curriculum is a teaching method that quickens the pace of teaching and learning a topic, thereby covering more material in a shorter amount of time. This differs from the curriculum compacting that occurs in gifted education, which involves choosing students who have already mastered prior material (usually through pre-testing) and then moving through new material more rapidly than the normal pace. For gifted students, this allows time for independent research and study, and tends to be used at the classroom level (Johnsen, 2005). In mathematics, which is highly sequential, compressing the curriculum allows students who are ready to move onto the next topic in the curriculum sequence at a quicker rate. Prior to middle school, this is often accomplished through gifted clusters in the classroom, but by middle school compressing the curriculum occurs through whole-class placement prescribed by school or school division policy decisions. For example, a condensed curriculum would schedule students into a blended course where they would learn both sixth and seventh grade math content in one academic year, or possibly learn sixth through eighth grade math content in two years instead of three. Compressing the curriculum has been shown to effectively raise performance of high-ability students on mathematics post-tests, and in addition improved student perception of the enjoyment of learning the mathematics (Reis & Renzulli, 1992). As compressing the mathematics curriculum is a linear rather than spiraling approach to learning mathematics, it is often a better match for high ability students (Rotigel & Fello, 2004).

A common complaint about eighth grade mathematics is that students don't really learn anything new as the curriculum tends to continually spiral back over previously learned content (Usiskin, 1987). In contrast to what happens in the rest of the world, U.S. math instruction in middle school, and particularly in eighth grade, does not take previously taught content to more complex levels, nor does it introduce challenging material that prepares students to learn in higher-level content in the later grades (AFT, 2003, p11). Consequently, our eighth graders are still studying basic material that their international peers have already mastered. Some school divisions design the curricular pathway to Algebra I in middle school by skipping content under the assumption that it is simply an extension of previously learned material. Skipping curriculum does have the consequence of directly affecting what will be taught in the Algebra I class. For example, if students skip the Math 8 curriculum under Virginia state standards, they will not have been taught how to solve anything beyond a two-step equation or one-step inequality (VDOE, 2009). The Algebra I curriculum assumes that students can solve multi-step equations that involve distributing, combining like terms, and dealing with variables on both sides of the equation. Without this foundation in place, the Algebra teacher must make time in instruction to include these skills in order for the Algebra I content to be understood.

A school division may choose to use a combination of compressing the curriculum and skipping math courses in order to move students further along the curriculum pathway. This combined method tends to be used with students who take Algebra I in seventh grade, followed by Geometry in eighth grade, and thus are two years ahead of their peers in mathematics learning.

Mathematics is an instructional area where opportunity to learn has a direct affect on achievement (Ysseldyke, Tardrew, Betts, Thill, & Hannigan, 2004, p.294). This is a direct function of teaching, and providing an opportunity to learn advanced content is a way to accelerate the learning of students who are ready to move forward. Increasingly in middle school mathematics this equates to beginning high school content while still in middle school.

Why Push Algebra I to Middle School?

Algebra in eighth grade used to be the domain of mathematically gifted students, yet now more eighth grade students take Algebra than any other math course (Loveless, 2008). Table 1 below shows how enrollment in eighth grade Algebra has increased over the past twenty years:

Table 1

U.S. Eighth Grade Enrollment in Algebra I

U.S. Eighth Grade Enrollment in Algebra I	
1990	16%
1996	25%
2003	33%
2011	47%

Note. Adapted from *The Nation's Report Card: Mathematics 2011* (NCES 2012–458). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, D.C. NCES, 2011.

Mathematics is by its nature sequential. One cannot do calculus unless you know the algebra needed to complete the problem; and one cannot do algebra unless you know the arithmetic needed to complete a solution. So why is Algebra I called the gateway course? A review of the content topics in the previous section shows the need for abstract thinking and reasoning in order to understand and use algebra at the Algebra I level. As discussed in the first section of this literature review, almost half of U.S. students are currently taking Algebra I in the eighth grade, and that trend is expected to continue. Why has the first high school credit-bearing mathematics class now moved to the middle school level? This section will explore how school divisions are arranging the mathematics curriculum in earlier grades so that students can take a high school math class while still in middle school. In conclusion, this segment will look at the benefits and drawbacks of taking Algebra I in middle school.

Graduation from High School

A majority of states now require Algebra I for high school graduation, as seen in Table 2.

Table 2

U.S. High School Mathematics: Number and Level of Mathematics Credits Required for Graduation

U.S. High School Mathematics Number and Level of Mathematics Credits Required for Graduation						
	# of Credits in Carnegie Units				Minimum level of math	
	Local Decision	2 math credits	3 math credits	4 math credits	Algebra I required	Algebra II or higher required
Number of states in 2001	6	17	24	4	N/A	N/A
Number of states in 2009	6	9	24	11	23	21 + DC

Note. Adapted from information provided in the *American Diploma Project (ADP) End of Course Exams: 2010 Report* by Achieve, Inc. (2010), NCES (2009) and NCES (2001).

In most states, low-level courses, such as consumer math, have either disappeared from the curriculum or only count as elective rather than math credit. Unless a student is graduating with a modified diploma, he/she will need to move beyond Algebra I in order to accumulate the mathematics credits needed for graduation.

The advent of block scheduling enables some students to take up to eight math classes in high school as opposed to just four, but it also requires learning more in less time, which proves difficult for many students. Students who find mathematics challenging may still need to take full-year courses for Algebra I, Geometry, and Algebra II in order to pass the classes and meet graduation requirements. Starting

Algebra I in eighth grade technically gives them an extra year to make it through the minimum number of courses even if there are failures along the way.

Failing Algebra I puts students at higher risk of not completing high school, yet Algebra I continues to generate the highest failure rate of any high school course (Stoelinga & Lynn, 2013). Taking Algebra I as an underprepared learner can leads students to experience repeated failures, and these students may never move on to Algebra II (Murray, 2012). Instead they are moved into other lower-level math classes so that they can earn enough credits to graduate.

College and Career Readiness

The more rigorous the course sequences a student experiences, the more likely he or she is to attend college (Schneider, Swanson, & Riegle-Crumb, 1998). In the 1950s, a college preparatory sequence would have included Algebra in ninth grade, followed by Geometry in tenth grade, Advanced Algebra in eleventh grade, and a trigonometry/functions class in twelfth grade (Usiskin, 1980). Students did not begin a formal study of calculus until they entered college. Today, students are expected to progress through a minimum of Algebra I, Geometry, Algebra II, and pre-calculus in order to reach calculus by twelfth grade. If a student delays taking Algebra until ninth grade, he has to complete three math courses in two years in order to take Calculus his senior year. Moving the introductory high school mathematics course of Algebra I to eighth grade facilitates this race to Calculus. Completing Algebra I in eighth grade also opens up opportunities in the science curriculum. Chemistry and physics both require at minimum completion of Algebra I prior to enrollment.

The American Diploma Project Network lists completion of 8^{th} grade mathematics in line with the CCSS-M or Algebra I with a "C" of higher by the end of 8^{th}

grade as an indicator of student readiness for college and career success (Achieve, 2013, p.4). Students planning on entering technology, health, science, and engineering fields are strongly encouraged to take Algebra I in eighth grade (Achieve, 2008) in order to take as much math as possible in high school. Students who want access to mathematics-based courses outside the college-prep sequence in high school (i.e., computer programming, statistics, and economics) must at a minimum pass Algebra I as a pre-requisite to enrolling.

Increasingly completing Algebra I is necessary not only for meeting requirements in mathematics coursework but also to prepare students for either college and/or career. Since the mid-1990s more and more eighth graders are completing this course prior to officially entering high school as a ninth grader. The next section will if and how this policy is succeeding in its goal of better preparing students for what comes after their K-12 education.

Algebra at the Middle School Level – Success or Failure?

Over the past two decades, the percentage of eighth grade students enrolled in Algebra I has grown from 16% to almost 50% (Loveless, 2013; NCES, 2010). Early research in this area focused on a specifically selected group of students who were accelerated in their mathematics learning onto a specific curriculum pathway that would enable them to take calculus in high school. Today, the demographic of students taking Algebra I in middle school has shifted towards students of average ability who may not necessarily want or have the ability to continue their mathematical learning through calculus. With the majority of states now requiring completion of a minimum of three years of mathematics at the level of Algebra I or above (Table 2), more students are being required or encouraged to take Algebra I prior to entering high school.

Beginning Algebra I in eighth grade places the student on a particular curricular pathway with social and instructional ramifications. Hoffer (1992) asserts that student placement exerts a powerful independent effect on achievement and attainments and explains part of the total effects of social class on these outcomes. On the other hand, Slavin's meta-analysis of research on tracking (1990) found that ability grouping has no significant overall effects on secondary school achievement. Mulkey (2005) and his fellow researchers found that eighth grade tracking has a long-lasting relationship with tenth grade social psychological variables and with a corresponding relationship to mathematics achievement in twelfth grade. Most researchers agree that eighth grade mathematics tracking is a significant predictor of where a student will be in twelfth grade (McFarland, 2006; Schneider et al., 1998; Stevenson et al., 1994). Since the impetus for a student taking Algebra I in middle school is to prepare him to take higher math in high school, does taking Algebra I by the eighth grade accomplish this goal?

Benefits of Taking Algebra I in Middle School

One of the first proponents of Algebra I in middle school, Zalman Usiskin went against the stance of NCTM by proposing that most students should begin Algebra in eighth grade rather than waiting until ninth (Usiskin, 1987). Compared to other countries, the content of a first-year Algebra course in the United States was comparable to what was studied by all students in grades 7 and 8 internationally. Even as early as 1987, Usiskin made the point that with the expansion of technology and the computer sciences, schools were going to need five years rather than four to give students access to all the math they would need postsecondary (Usiskin, 1987). Starting Algebra earlier would reduce pressure on students to complete the college-prep sequence of mathematics and better prepare them for what lay ahead.

Students who take algebra earlier rather than later have subsequently higher math skills (Loveless, 2008), and 83% of students who take Geometry in ninth grade complete Calculus or another advanced math course during high school (Smith, 1996). Taking Algebra I in eighth grade was found to have the greatest impact on Grade 9 achievement, followed by Pre-Algebra, Algebra I Honors, and Geometry, whereas the courses that students took in Grade 9 did not predict Grade 10 achievement (Ma, 2000).

Taking Algebra I in the eighth grade sets the student on a curricular pathway that could include the completion of calculus by twelfth grade (Smith 1996). This provides a positional advantage to the student when he begins high school. Due to the sequential nature of mathematics, the student would be ready to begin Geometry in the ninth grade (Schneider, Swanson, & Riegle-Crumb, 1998) which sets up a clear pathway to calculus regardless of either traditional or block scheduling. This is important for college planning, as the more rigorous the course sequences a student experiences, the more likely he or she is to attend college (Schneider, Swanson, & Riegle-Crumb, 1998). More math classes and taking advanced math classes in high school enhanced earnings ten years after high school graduation, even after accounting for differences such as demographics, high school characteristics, and eventual educational attainment (Rose & Betts, 2001).

Algebra-for-all policies have increased the number of minority and low-income students who have access to Algebra in middle school. Completing Algebra in the eighth grade opens up the possibility of completing more challenging mathematics coursework in high school, which in turn increases the likelihood of graduating from high school, enrolling in college, and moving into a successful postsecondary career (Spielhagen, 2008; Stoelinga & Lynn, 2013). Raising the expectations for all students has shown to improve opportunities for low-income and minority students as long as there are equitable, data-informed placement decisions made (Stoelinga & Lynn, 2013).

Ma (2005) reported that low-achieving students taking Algebra I in eighth grade showed greater growth in mathematics achievement than those students placed into a regular eighth grade math course. An analysis of national survey data by Gamoran and Hanigan (2000) found that Algebra enrollment was associated with higher mathematics achievement for all students, although it provided less of an advantage to those students with lower initial achievement levels.

Smith (1996) found that early access to Algebra positively affected high school mathematics achievement and attitudes. At the time of the study, fewer students were enrolled in Algebra I, and Smith cautions that the results might not hold for all students taking Algebra I in eighth grade. Some studies on universal math acceleration (algebra-for-all) have shown promise. A New York middle school eliminated tracking and prepared all sixth and seventh graders to take the accelerated algebra course normally reserved for high achievers (Burris, Heubert & Levin, 2004). With strong support systems in place (tutoring, extra class time) the policy change positively affected students across subgroups, particularly as it related to continuing to take higher level mathematics in high school. A study of California students showed that increased pass-proficient scores on the CST for Algebra I correlated with more students scoring pass-proficient on the Summative High School Mathematics CST in eleventh grade (Liang, Heckman, &

Abedi, 2012). However, while more students were enrolling in Algebra earlier, the number of these students going on to higher math diminished (Liang, Heckman, & Abedi, 2012).

Drawbacks of Taking Algebra I in Middle School

One of the impetuses behind the policy of having students complete Algebra in eighth grade was to reduce the inequities that existed for minority and low-income students, who rarely moved on to higher level math classes in high school and were less likely to go to college after graduation. Many of the students currently taking Algebra in eighth grade attend school in large urban districts such a Chicago, Philadelphia, Los Angeles, and Washington, DC. However, research indicates that the algebra-for-all policy has neither increased the standardized test scores for mathematics nor increased the likelihood of students attending college (Stoelinga & Lynn, 2013). Washington, DC – with one of the highest Algebra I enrollments in the country – scored last place on the 2007 NAEP (Loveless, 2008). In fact, Algebra I continues to produce the highest failure rate of any single mathematics course in the years since the policy was enacted (Nomi, 2012).

For example, California has had an algebra-for-all policy in place since the late 1990s, strongly encouraging all students to enroll in Algebra I in eighth grade (EdSource, 2011). Student enrollment in Algebra I in eighth grade has increased from 16% in 1999 to over 50% (EdSource, 2011). Results from the California Standards Test (CST) Algebra I assessment shows that while 1.8 as many eighth graders passed the test in 2008 compared to 2003, 1.5 as many students also <u>failed</u> the test (Stoelinga & Lynn, 2013). In addition, students who failed the test the first time continued to fail on subsequent attempts. In 2011, only 20% of students repeating the Algebra I CST passed on their second attempt (EdSource, 2011) and dropped to 10% for students in Grades 10-11 (Finkelstein, Fong, Tiffany-Morales, Shields, & Huang, 2012).

California's Algebra policy strongly affected students in inner city schools in Los Angeles, where students scoring below basic are routinely enrolled in Algebra I for the eighth grade (EdSource, 2009). Undertaking Algebra I as an underprepared learner and failing leads the student to experience reinforcing patterns of failure which can affect the student's self-efficacy belief of being able to earn a high school diploma, particularly if two or three more math classes are required beyond Algebra I in order to satisfy graduation requirements. In 2010 the California Court of Appeals upheld an injunction to prohibit the California State Board of Education from mandating the use of the Algebra I CST as the sole measure of eighth grade mathematics achievement, citing the high costs to school districts forced to comply (Fagen, Friedman, & Fulfrost, 2010).

Charlotte-Mecklenburg schools adopted an algebra-for-all policy in 2002-2003 by dramatically increasing the percentage of moderately-performing students from less than 50% to more than 90% in the span of one school year in the hopes of moving those students further along in high school mathematics. Students who were part of the acceleration initiative scored lower on the end-of-course test for Algebra I and were either no more likely or significantly less likely to pass tests for either Geometry or Algebra II (Clotfelter, Ladd, & Vigdor, 2012). Higher ability students also suffered, as data showed that many accelerated students who went on to pass Algebra II never passed Geometry, thereby not truly completing the college-preparatory math sequence (Vigdor, 2013). Implementation issues are cited as contributing to the failure of this algebra-for-all initiative as many students did not have sufficient instructional preparation prior to taking Algebra I. The policy was abandoned after only two years.

In 2003 Chicago Public Schools ended remedial classes and placed all students on a college-preparatory track for math and English, which entailed taking Algebra I in by the end of ninth grade. Inequity issues due to race and entering ability were eliminated, more students received credits in Algebra, and there was no increase in dropout rates in spite of increased class rigor (Allensworth, Nomi, & Montgomery, 2009). Unfortunately, failure rates increased on the end-of-course test, grades declined and students were no more likely to enter college, which was the main goal of implementing the policy.

If one of the reasons for adopting an algebra-for-all policy is to provide more students with the means to complete more mathematics courses in high school and have a better foundation for attempting post-secondary studies, is this really working out? Only 46% of students taking the ACT test in 2012 met the mathematics target for college readiness, with that target being the ability to completed College Algebra with a grade of "B" or better (ACT, 2012). For African American and Hispanic students the percentages were even lower, at 15% and 31% respectively (ACT, 2012). Students who graduate high school having taken so-called advanced classes such as trigonometry and pre-calculus may still find themselves needing remedial mathematics courses at the college level (Loveless, 2013). In 2008 an estimated 44% of community college students and 27% of public four-year college students needed to take a remedial mathematics course (Alliance for Excellent Education, 2011). Furthermore, 80% of these students had maintained at least a 3.0 GPA in high school.

There has been little or no progress in improving NAEP scores. With 47% of students taking Algebra I in 2011 compared to only 33% in 2003 (NCES, 2012), one would expect to see a bump up in NAEP scores due to more students completing a higher level of mathematics. Scores for eighth grade students increased 7 points from 2003 data but only 1 point from the 2009 assessment, and for larger urban areas such as Los Angeles and Chicago over 50% of students still scored Below Basic (NCES, 2011). Tom Loveless, a senior fellow at the Brookings Institute, found no connection between increases in the number of eighth grade students enrolled in Algebra I and higher scores on the 2011 NAEP, even after controlling for demographics (Loveless, 2013). NAEP's high school transcript study found "college ready" to be a term that was widely-interpreted by different schools, with some courses devoting up to 21% of instruction to elementary and middle school math and two-dimensional geometry (Brown, Schiller, Roey, Perkins, Schmidt, & Houang, 2013). with the high school transcript study, Loveless's assertion that some students taking Algebra I in eighth grade are receiving water-downed curriculum seems to hold true.

The incorporation of algebra-for-all policies has resulted in a shift of population demographics for students enrolled in Algebra I. While much of this is positive – more minority and low-income students have access to Algebra I in middle school – it has also resulted in classes that are heterogeneous in regards to student mathematical ability. Unless a school division or school makes the decision to provide leveled classes in order to provide a more homogeneous grouping arrangement for students, an Algebra I class will be made up of students with wide-ranging abilities (Nomi, 2012). For example, when students are grouped homogeneously, the teacher will plan instruction that targets their abilities. For high-ability students, this could include more challenging content with higher expectations overall for achievement (Nomi, 2012). Differentiating (leveling) the curriculum tends to adversely impact students in low level courses compared to high track ones, as it tends to exacerbate achievement inequalities (Michigan State University, 2008) and can lead to a watering-down of the curriculum in order to match student ability levels (Loveless, 2008). Lower ability students may find themselves in a course labeled "Algebra I" that is more likely to resemble a pre-algebra course, with slower-paced instruction and less-emphasis on problem solving and higher order thinking skills (DiME, 2007).

Conclusions from This Research

Much of the policy push to place all or at least more students in Algebra I in eighth grade was based on studies conducted in the mid-1990s (Ma, 2000; Smith, 1996). These studies showed a positive correlation with starting Algebra before beginning high school and completing higher math courses in high school, and were interpreted as causal by policy makers (Loveless, 2008). In an attempt to rectify equity issues which were also identified at the time, school divisions moved to place more students into Algebra courses by eighth grade, assuming that this would give all students an equal opportunity to achieve more in mathematics prior to high school graduation (Loveless, 2008). Thus social justice was served, and theoretically more students from all backgrounds would be able to achieve more in mathematics.

While the policies intended to increase equity for students by requiring completion of Algebra I by the end of eighth or ninth grade, evidence shows that for many students simply enacting these policies has neither increased mathematics achievement or nor provided more opportunities (Stoelinga & Lynn, 2013). While eliminating curricular pathways and adopting a de-tracked approach to Algebra I was thought to improve educational opportunities for all students, research in the past 10 years is showing that this is often not the case. While the push for increasing the number of students participating in Algebra I in eighth grade has been successful, are these students truly being successful in learning mathematics? Participation does not necessarily equate to proficiency.

One commonality of the research on eighth grade Algebra is that equity needs to take the form of better preparation for Algebra I, not just the offering of the course itself. As Usiskin points out, preparing students to take Algebra in eighth grade begins back in elementary school (Usiskin, 1987). NCTM's recommendations have helped spread algebraic thinking throughout the K-8 curriculum. The National Math Panel's recommendations to improve student learning on the topic of fractions will also help better prepare students for middle school and high school mathematics. The Common Core standards for mathematics may provide a national cohesive curriculum at last.

Researchers also agree that an Algebra I course regardless of whether it is taken in middle school or high school should include rigor for all students in order to maximize opportunity to complete higher math courses successfully (Loveless, 2011; Stoelinga & Lynn, 2013). In fact one of the greatest concerns among educational policy researchers is that as more students enroll in Algebra I prior to high school the course itself may become watered-down to match the lower ability level of some students (Loveless, 2011). Virginia, with strong standards in mathematics preparation leading up to high school and a set course of study for Algebra I, is a good place to look for evidence that better preparation in earlier grades is equaling Algebra I achievement for eighth grade students.

Curricular Pathways and Outcomes in Virginia

The development of mathematics education in Virginia closely parallels that of the nation. An early adopter of state education standards, Virginia has continued to update and refine its standards and methods of assessment to match current research and national policy, and it remains ahead of other states that are just now moving forward with plans to implement Common Core and a technology-based assessment system. This section will take a closer look at the state of affairs in Virginia and make the case for using Virginia as a research basis concerning curricular pathways to Algebra I in middle school.

Early Adopter of State Standards

As early as the mid-1980s Virginia had adopted content standards as guidelines for school divisions to use in planning their curriculums (Virginia Board of Education, 1983). In 1995, the Virginia Department of Education (VDOE) decided to build upon this foundation by formally approving the *Standards of Learning* in four core content areas, including mathematics. (Commonwealth of Virginia, 1995). The following year standardized assessments were developed to correspond to the *Standards of Learning*, and in 1997 the Virginia Board of Education linked statewide accountability based on test scores to school accreditation. This action placed responsibility for achievement not only on the student but also on the schools and school divisions the child attended. The Standards of Quality informed the public of the school divisions' responsibilities, while the Standards of Accreditation did the same for individual schools (Pilling, 1999). The

Standards of Learning directed what Virginia students should learn, and local schools and school divisions would be held accountable for making sure those students did learn.

An early adopter of state standards, Virginia became a model for other states (Ravitch, 1997) by clearly specifying what students should learn at each grade level (curriculum), dictating how that learning would be measured (testing), and placing responsibility for learning on all educational shareholders (accountability). The American Federation of Teachers praised Virginia for having clear, focused and well-grounded standards that specified grade-by-grade and course-by-course structure and content (AFT, 1997). Virginia began providing report cards on a school-by-school and division basis so that the public had access to test scores and other academic indicators. In 2000 the State Board of Education also called for ongoing revision of the standards every seven years (VBOE, 2009).

Rigorous Graduation Requirements

Prior to implementing the *Standards of Learning* tests, Virginia students only needed to pass a sixth grade level test in order to graduate from high school, which resulted in almost 25% of college freshman needing remedial help in reading and mathematics (SCHEV, 1989). The 1995 mathematics standards placed more emphasis on preparing all students to take Algebra in high school and removed such courses as General Math, Consumer Math and Applied Math from the high school curriculum (Pilling, 1999). Virginia students were allowed to substitute a vocational-technical or ROTC class to satisfy math requirements (Educational Commission of the States, 1994), but Algebra I was an expected course of most high school students. Not only was Algebra I expected, the requirements of the course were specifically stated so that school divisions could not use a watered-down version of the curriculum in order to boost graduation rates.

Virginia's mathematics requirements for graduation have become more rigorous over the past 15 years as well, as seen in Figure 8 below. Currently Algebra I is the lowest level of math course allowed to count towards graduation requirements, and it requires an End-of-Course (EOC) test at the completion of coursework. In order to earn a Standard Diploma, Virginia students must complete three standard credits in mathematics, meaning that the student passes the course but does not necessarily pass the associated SOL-EOC test (VDOE, 2007). One of these standard credits must also be verified credit where in addition to passing the course the student receives a passing score on the corresponding SOL-EOC test (VDOE, 2007). For most students, that test is the Algebra I EOC test.

Figure 8

Changes in Virginia Graduation Requirements

Changes in Virginia Graduation Requirements		
Standard Diploma		
Verified Credits Entering 9th grade 2003-current	Standard Credits Entering 9th grade 2003-2010	Standard Credits Entering 9th grade 2011-current
1	3 Courses completed to satisfy this requirement shall be at or above the level of algebra and shall include at least two course selections from among: Algebra I, Geometry, Algebra II or other mathematics courses above the level of algebra and geometry. The Board may approve additional courses to satisfy this requirement.	3 Courses completed to satisfy this requirement shall include at least two different course selections from among: Algebra I; Geometry; Algebra, Functions and Data Analysis; Algebra II or other mathematics courses above the level of Algebra II. The Board shall approve courses to satisfy this requirement.
Advanced Diploma		
Verified Credits Entering 9th grade 2003-current	Standard Credits Entering 9th grade 2003-2010	Standard Credits Entering 9th grade 2011-current
2	4 Courses completed to satisfy this requirement shall be at or above the level of algebra and shall include at least three different course selections from among: Algebra I, Geometry, Algebra II or other mathematics courses above the level of Algebra II. The Board may approve additional	4 Courses completed to satisfy this requirement shall include at least three different course selections from among: Algebra I, Geometry, Algebra II or other mathematics courses above the level of Algebra II. The Board shall approve courses to satisfy this requirement

Note. Information obtained from VDOE website (2013).

A Valid and Reliable State Assessment System

Virginia's *Standards of Learning* tests are criterion-referenced, valid and reliable. The tests are revised and reviewed yearly by a committee of Virginia teachers and math specialists from throughout Virginia who then work directly with the testing company during a week-long summer session. Designated by grade level, the committees examine previously tested questions (countable and/or field-tested) to ensure statistical reliability and validity. The committee also examines all forms of the upcoming school year's assessment, once again ensuring that the test questions match the standards they are assessing. As a final step, the committee examines and approves questions to be used for field testing on future SOL tests, after reviewing each item for content match, visual accuracy, and possible bias or validity issues (VDOE, 2013c).

The majority of Virginia's students take their SOL test on a computer. During 2012-2013, more than 3 million assessments were administered online (VDOE, 2013a). The use of technology-based testing provides for greater test security, less opportunity for student cheating, and more quickly tabulated results. Mathematics tests now include technology-enhanced items (TEIs) which require students to indicate their responses in ways other than just multiple-choice, which in turn can increase the cognitive level of these assessment items.

A student must get 50% percent (scaled score of 400) or higher on their SOL(s) in order to pass the test. Passing with 88% percent (500 or higher as a scaled score) is considered advanced/proficient. A perfect score is 600 (VDOE, 2009). While the SOL tests provide an assessment of mastering topics at a specific grade level, a student's advancement to the next grade in school is not contingent on passing any SOL test at the K-8 level. Only SOL tests labeled End-of-Course (EOC) can prevent a student from moving forward to the next class level. Algebra I EOC is first in the EOC sequence, followed by Geometry EOC and Algebra II EOC. Students scoring between a 375 and

400 on an EOC mathematics test are eligible to take an expedited retake of the test following a minimum of one hour targeted tutoring by a teacher on the student's areas of weakness.

Standards with Substance

Virginia is the only state found to have met 100% of the American Federation of Teachers criteria for strong standards in all subjects and at all grade levels (AFT, 2008). Virginia had already begun its cycle of revisions towards the *2009 Mathematics Standards of Learning* when the National Math Panel published its report in 2008. As stated in the prior sections, Virginia chose not to adopt the Common Core State Standards – Mathematics (CCSS-M). Having updated the *Virginia Standards of Learning for Mathematics* in 2009, the Virginia Board of Education felt that the current standards in use were equal to or in some cases more rigorous than the CCSS-M, particularly in grades K-7 (VDOE, 2011). Virginia also balked at the CCSS-M's dictating of teaching methodologies, preferring that those pedagogical choices be left in the hands of Virginia's teachers (VDOE, 2011).

Process Standards

Virginia's *2009 Standards of Learning* includes an introductory section which specifies the process standards that apply to grades K-12 (VDOE, 2009). Referred to as "Goals," Virginia's process standards are streamlined yet able to be interpreted as needed for students of different ages and abilities. The introduction states the need for "more rigorous mathematical knowledge and skills to pursue higher education," (VDOE, 2009, p.iv) and the need to employ various tools and methods when doing math. The introduction also stresses the use of technology as a tool rather than a substitute for conceptual understanding (VDOE, 2009, p.iv). Figure 9 shows Virginia's five mathematics process goals.

Figure 9

Virginia Standards of Learning Mathematics Process Standards 2009

Virginia Standards of Learning Mathematics Process Standards 2009 Adapted from *2009 Mathematics Standards of Learning* (VDOE, 2009)	**Mathematical Reasoning** Students will recognize reasoning and proof as fundamental aspects of mathematics. Students will learn and apply inductive and deductive reasoning skills to make, test, and evaluate mathematical statements and to justify steps in mathematical procedures. Students will use logical reasoning to analyze an argument and to determine whether conclusions are valid. In addition, students will learn to apply proportional and spatial reasoning and to reason from a variety of representations such as graphs, tables, and charts.
Mathematical Problem Solving Students will apply mathematical concepts and skills and the relationships among them to solve problem situations of varying complexities. Students also will recognize and create problems from real-life data and situations within and outside mathematics and then apply appropriate strategies to find acceptable solutions. To accomplish this goal, students will need to develop a repertoire of skills and strategies for solving a variety of problem types. A major goal of the mathematics program is to help students become competent mathematical problem solvers.	**Mathematical Connections** Students will relate concepts and procedures from different topics in mathematics to one another and see mathematics as an integrated field of study. Through the application of content and process skills, students will make connections between different areas of mathematics and between mathematics and other disciplines, especially science. Science and mathematics teachers and curriculum writers are encouraged to develop mathematics and science curricula that reinforce each other.
Mathematical Communication Students will use the language of mathematics, including specialized vocabulary and symbols, to express mathematical ideas precisely. Representing, discussing, reading, writing, and listening to mathematics will help students to clarify their thinking and deepen their understanding of the mathematics being studied.	**Mathematical Representations** Students will represent and describe mathematical ideas, generalizations, and relationships with a variety of methods. Students will understand that representations of mathematical ideas are an essential part of learning, doing, and communicating mathematics. Students should move easily among different representations-- graphical, numerical, algebraic, verbal, and physical -- and recognize that representation is both a process and a product.

Content Standards

Virginia's *Standards* align with the CCSS-M content, although not necessarily at the same grade level (VDOE, 2011). Some of the CCSS-M Grade 8 topics are covered in Math 7 in Virginia, while others (e.g., slope of a line, solving systems of equations) are not fully taught until Algebra I in Virginia. Nevertheless, Virginia's standards do complete the high school requirements specified in CCSS-M, and therefore are aligned with what is now a predominantly national curriculum for Algebra.

Key Concepts for Algebra I success.

The critical foundations for success in Algebra I, as identified in the second section of this literature review, are shown in Figure 10. Also included is their placement in the Virginia Standards of Learning by grade level. As part of the revisions to the 2009 SOLs, the Virginia Board of Education increased the rigor and cognitive level of topics, particularly those at the upper elementary and middle school level (VDOE, 2009), thus enabling a shift to lower grades in some topics related to future algebraic success.

Figure 10

Key Concepts for Algebra I Success: Grade Placement in the Virginia Standards of Learning

Key Concepts for Algebra I Success as determined by NMAP (2008) and NCTM (2006) Grade Placement in the Virginia Standards of Learning*			
	Year of Adoption		
	1995	2001	2009
1. Addition & subtraction of whole numbers	3 & 4	3 & 4	3 & 4
2. Multiplication & division of whole numbers	4 & 5	4 & 5	4
3. Identify and represent fractions and decimals, compare them on a number line or with other common representations of fractions and decimals	4 & 5	4 & 5	
4. Compare fractions and decimals and common percents	6	6	6
5. Add and subtract fractions and decimals	4 & 5	4 & 5	3, 4, 5
6. Multiply and divide fractions and decimals	6	6	6
7. Integer operations	7	7	7
8. Operations with positive and negative fractions	----	---	----
9. Solve problems involving percent, ratio, and rate and extend this work to proportionality	7	7	7
10. Solve problems involving perimeter and area of triangles and of all quadrilaterals having at least one pair of parallel sides (i.e., trapezoids)	7 & 8	7	7
11. Analyze the properties of two-dimensional shapes and solve problems involving perimeter and area	7	6 & 7	5 & 6
12. Analyze the properties of three-dimensional shapes and solve problems involving surface area and volume	7	7	5,6,7
13. Be familiar with the relationship between similar triangles and the concept of the slope of a line	Alg I	Alg I	8
14. Simplify expressions using order of operations	7	6 & 7	5
15. Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and when possible, symbolic rules	8	6 & 7	6 & 7
16. Relate and compare different forms of representation for a relationship	8	7	7
17. Identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations	Alg I	Alg I	8
18. Develop an initial conceptual understanding of different uses of variables	5,6,7	5,6,7	5,6,7
19. Explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope	Alg I	Alg I	8
20. Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships	7 & 8	7 & 8	6,7,8
21. Recognize and generate equivalent forms for simple algebraic expressions and solve linear equations	8	7	7
22. Model and solve contextualized problems using various representations, such as graphs, tables, and equations	8	8	7
23. Use graphs to analyze the nature of changes in quantities in linear relationships	Alg I	8	7

Note. #1-13 relate to NMAP (2008), #14 is provided by the author, and #15-23 relate to NCTM (2006).

Fractions.

An understanding of fractions is deemed critical to algebraic understanding by both NCTM (2006) and NMAP (2008). With the adoption of the 2009 Standards, Virginia began the introduction of fractions at a much earlier grade than previously. Prior to the *2009 Standards*, fractions were not introduced at all until Grade 1. Representation of thirds were not included until Grade 3 and sixths not until Grade 4, both of which are now included in Grade 2. Comparing and ordering fractions moved down to Grade 4, which makes sense as students have had a much earlier exposure and more practice with fractions than in the previous years (VDOE, 2009; VDOE, 2001). By providing an earlier and more rigorous exposure to fractions, Virginia responded directly to the National Math Panel's recommendations to improve preparedness for Algebra I. Figure 11 shows how the topic of fractions is developed across grade levels in Virginia.

Figure 11

2009 Virginia Mathematics Standards of Learning Vertical Articulation of Fractions

2009 Virginia Mathematics Standards of Learning Vertical Articulation of Fractions	
Grade Level	Concept
Kindergarten	K.5 The student will identify the parts of a set and/or region that represent fractions for halves and fourths.
Grade 1	1.3 The student will identify the parts of a set and/or region that represent fractions for halves, thirds, and fourths and write the fractions.
Grade 2	2.3 The student will: a) identify the parts of a set and/or region that represent fractions for halves, thirds, fourths, sixths, eighths, and tenths; b) write the fractions; and c) compare the unit fractions for halves, thirds, fourths, sixths, eighths, and tenths.
Grade 3	3.3 The student will: a) name and write fractions (including mixed numbers) represented by a model; b) model fractions (including mixed numbers) and write the fractions' names; and c) compare fractions having like and unlike denominators, using words and symbols (>, <, or =).
Grade 4	4.2 The student will: a) compare and order fractions and mixed numbers; b) represent equivalent fractions; and c) identify the division statement that represents a fraction. 4.5 d) solve single-step and multistep practical problems involving addition and subtraction with fractions and with decimals.
Grade 5	5.2 The student will: a) recognize and name fractions in their equivalent decimal form and vice versa; and b) compare and order fractions and decimals in a given set from least to greatest and greatest to least. 5.6 The student will solve single-step and multistep practical problems involving addition and subtraction with fractions and mixed numbers and express answers in simplest form.
Grade 6	6.2 The student will: a) investigate and describe fractions, decimals, and percents as ratios; b) identify a given fraction, decimal, or percent from a representation; c) demonstrate equivalent relationships among fractions, 6.4 The student will demonstrate multiple representations of multiplication and division of fractions. 6.6 The student will: a) multiply and divide fractions and mixed numbers; and b) estimate solutions and then solve single-step and multistep practical problems involving addition, subtraction, multiplication, and division of fractions.

Note. Adapted from the *2009 Mathematics Standards of Learning.* (VDOE, 2009)

Algebraic Concepts.

The changes from the 2001 to the 2009 Standards of Learning show a shift to lower grade levels of the introduction and/or mastery of topics, particularly those dealing directly with the strand of Patterns, Functions & Algebra (VDOE, 2009). Earlier introduction of a topic would give more time for mastery and provide a clearer path to Algebra I for students who are ready to move on after Math 7; however, there are still topics deemed foundational that are not included in Virginia's curriculum until Math 8.

Students need systematic exposure to algebra throughout their school career, not just in the year prior to attempting a formal course in Algebra (Stoelinga & Lynn, 2013). Virginia's standards thread algebraic concepts throughout the K-12 curriculum to provide a strong basis in algebraic thinking prior to high school. As such, the Algebra I curriculum can be taught at high level of rigor if students have already been exposed to many of the basic concepts behind solving equations and working with functions. Figure 12 below shows the vertical articulation of algebraic concepts in the *2009 Virginia Mathematics Standards of Learning.*

Figure 12

2009 Virginia Mathematics Standards of Learning Algebraic Concepts Across Grade Levels

2009 Virginia Mathematics Standards of Learning Algebraic Concepts Across Grade Levels	
Grade Level	Concept
Kindergarten	K.15 The student will sort and classify objects according to attributes. K.16 The student will identify, describe, and extend repeating patterns.
First Grade	1.16 The student will sort and classify concrete objects according to one or more attributes, including color, size, shape, and thickness. 1.17 The student will recognize, describe, extend, and create a wide variety of growing and repeating patterns. 1.18 The student will demonstrate an understanding of equality through the use of the equal sign.
Second Grade	2.20 The student will identify, create, and extend a wide variety of patterns. 2.21 The student will solve problems by completing numerical sentences involving the basic facts for addition and subtraction. The student will create story problems, using the numerical sentences. 2.22 The student will demonstrate an understanding of equality by recognizing that the symbol = in an equation indicates equivalent quantities and the symbol ≠ indicates that quantities are not equivalent.
Third Grade	3.19 The student will recognize and describe a variety of patterns formed using numbers, tables, and pictures, and extend the patterns, using the same or different forms. 3.20 The student will: a) investigate the identity and the commutative properties for addition and multiplication; and b) identify examples of the identity and commutative properties for addition and multiplication.
Fourth Grade	4.15 The student will recognize, create, and extend numerical and geometric patterns. 4.16 The student will: a) recognize and demonstrate the meaning of equality in an equation; and b) investigate and describe the associative property for addition and multiplication.
Fifth Grade	5.17 The student will describe the relationship found in a number pattern and express the relationship. 5.18 The student will: a) investigate and describe the concept of variable; b) write an open sentence to represent a given mathematical relationship, using a variable; c) model one-step linear equations in one variable, using addition and subtraction; and d) create a problem situation based on a given open sentence, using a single variable. 5.19 The student will investigate and recognize the distributive property of multiplication over addition.

Grade Level	Concept
Sixth Grade	6.17 The student will identify and extend geometric and arithmetic sequences. 6.18 The student will solve one-step linear equations in one variable involving whole number coefficients and positive rational solutions. 6.19 The student will investigate and recognize: a) the identity properties for addition and multiplication; b) the multiplicative property of zero; and c) the inverse property for multiplication. 6.20 The student will graph inequalities on a number line.
Seventh Grade	7.12 The student will represent relationships with tables, graphs, rules, and words. 7.13 The student will: a) write verbal expressions as algebraic expressions and sentences as equations and vice versa; and b) evaluate algebraic expressions for given replacement values of the variables. 7.14 The student will: a) solve one- and two-step linear equations in one variable; and b) solve practical problems requiring the solution of one- and two-step linear equations. 7.15 The student will: a) solve one-step inequalities in one variable; and b) graph solutions to inequalities on the number line.
Eighth Grade	8.14 The student will make connections between any two representations (tables, graphs, words, and rules) of a given relationship. 8.15 The student will: a) solve multistep linear equations in one variable with the variable on one and two sides of the equation; b) solve two-step linear inequalities and graph the results on a number line; and c) identify properties of operations used to solve an equation. 8.16 The student will graph a linear equation in two variables. 8.17 The student will identify the domain, range, independent variable, or dependent variable in a given situation.

Note. Adapted from the *2009 Virginia Mathematical Standards of Learning* (VDOE, 2009).

Clear Mathematical Focus for Each Grade Level

Another change from the 2001 to the 2009 Mathematics Standards of Learning was the inclusion of a focus statement for each mathematical strand at each grade level. Targeted outcomes for each grade level can help school divisions in planning curricular pathways as it is much more obvious what the expected learning outcomes are for each grade level of math. School divisions can then make the decision whether to condense some grade levels together or possibly to skip a grade level's content altogether.

Figure 13 below shows these focus statements for Math 5 through Math 8.

Figure 13

2009 Virginia Mathematics Standards of Learning Focus Statements by Strand and Grade Level

2009 Virginia Mathematics Standards of Learning Focus Statements by Strand and Grade Level				
	Math 5	Math 6	Math 7	Math 8
Number & Number Sense	Prime and composite numbers and rounding decimals.	Relationships among fractions, decimals, and percents	Proportional reasoning	Relationships within the real number system
Computation & Estimation	Multi-step applications and order of operations.	Applications of operations with rational numbers	Integer operations and proportional reasoning	Practical applications of operations with real numbers
Measurement	Perimeter, area, volume, and equivalent measures	Problem solving with perimeter, area, volume, and surface area	Proportional reasoning	Problem solving
Geometry	Classification and subdividing	Properties and relationships	Relationships between figures	Problem solving with 2- and 3-dimensional figures
Probability & Statistics	Outcomes and measures of center	Practical applications of statistics	Applications of statistics and probability	Statistical analysis of graphs and problem situations
Patterns, Functions & Algebra	Equations and properties	Variable equations and properties	Linear equations	Linear relationships

Note. Adapted from the *2009 Virginia Mathematical Standards of Learning* (VDOE, 2009).

The information contained in Figures 9 through 13 shows the abbreviated version of essential information contained in Virginia Curriculum Frameworks documents (VDOE, 2009). The streamlined Focus Statements belies the increase in detail found in the *Curriculum Frameworks* used by educators to plan and implement teaching the standards in the classroom. The *2009 Standards* involved a significant increase in rigor and cognitive level over previous *Standards*, particularly for teachers of upper elementary school (Grades 4 and 5). The corresponding state assessments – implemented fully for the first time during the 2011-2012 school year – mirrored these increases as well and provide the initial data analysis points for this study.

Curricular Pathways to Completing Algebra I in Eighth Grade

The number of Virginia students taking Algebra I in eighth grade has risen from just over 30,000 students in 2008-2009 to almost 44,000 students in 2011-2012, an increase of 54% (VDOE, 2013). Enrollment increased dramatically as well between 2010-11 and 2011-12, from 35,729 to 43,510, an increase of about 22%. This enrollment would increase even further the next year to 48,620 students taking the Algebra I EOC course, over an 11% increase again from the prior year (VDOE, 2013). Based on the numbers, many more Virginia students were taking Algebra I as an eighth grade student prior to entering high school.

The Algebra I EOC test for the 2011-2012 school year was based solely on the 2009 Standards and had an increased emphasis on rigorous questions, including 5-10% of the test questions which were technology-enhanced items (TEIs) requiring student-input answers as opposed to only multiple choice. Table 3 below shows the score differences that occurred over a three year period, and it is obvious to see the effects these changes wrought on student scores.

Table 3

Comparison of Algebra I EOC Scores for Eighth Grade Students

Comparison of Algebra I EOC Scores for Eighth Grade Students					
	Overall Pass Rate	Pass Advanced	Pass Proficient	Fail Basic	Average Score
2010-2011	98.77%	46.32%	50.05%	1.23%	502.21
2011-2012	89.93%	14.37%	75.57%	10.07%%	449.52
2012-2013	90.93%	16.08%	74.86%	9.07%	452.13

Note. Adapted from data obtained from Virginia Department of Education, November 11, 2013.

With participation rates holding steady, 4,933 eighth grade students failed the Algebra I EOC test in 2011-2012 compared to only 552 students in 2010-2011, and these numbers would include any students who were not able to pass utilizing the expedited retake option. In addition, the number of students who earned Pass Advanced dropped from 21,917 in 2010-11 to 7,040 in 2011-12, a percent decrease of 68%.

Cut-scores for the Algebra I EOC test also changed. From October, 2008 until the 2012-2013 tests, students had to answer a minimum of 27 out of 50 questions correctly (54%) to achieve a passing score of 400 or higher which is Pass Proficient, and a minimum of 45 out of 50 questions (90%) to attain Pass Advanced (VDOE, 2013c). On January 12, 2012, the Virginia Board of Education dropped the cut-score for the Algebra I EOC exam to 25 out of 50 questions (50%) to pass with a score of 400 while the Pass Advanced designation remained at 45 out of 50 (90%) (VDOE, 2013c).

Even with the cut-score offset, pass rates remained low in 2012-2013. The increased testing rigor and an increase in the number of students taking the Algebra I

EOC test as an eighth grader seem to have caused a sharp decline in achievement scores starting in the 2011-2012 school year.

Curricular Pathways.

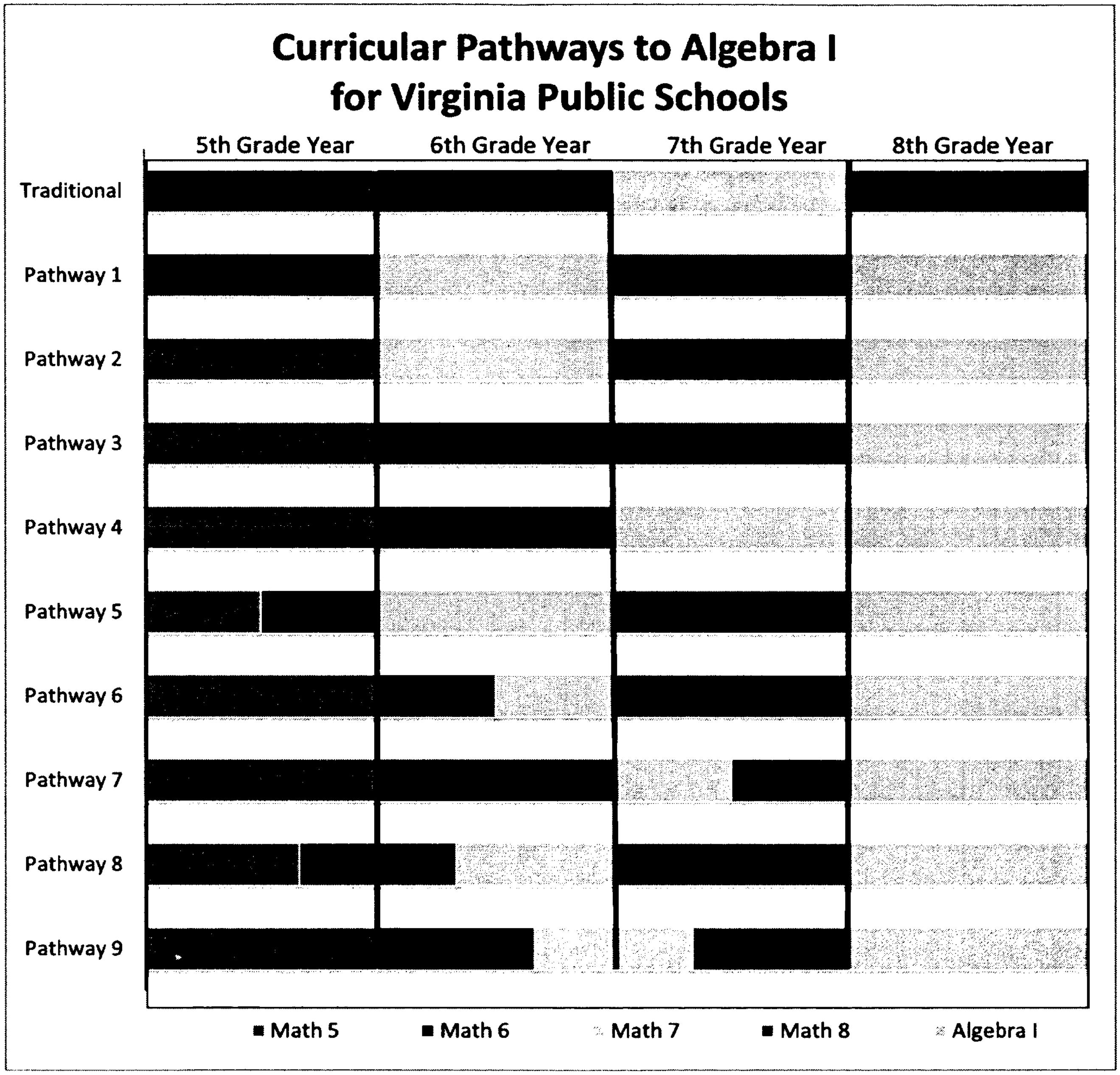
As explored in the second section of this literature review, in order to take Algebra I in eighth grade, a student must somehow move more quickly through the prescribed mathematics curriculum. The same is true in Virginia, where Algebra I is considered the first high school mathematics course and has an End of Course (EOC) exam connected to it. School divisions can determine when students enter the pathway to complete Algebra I in eighth grade and what curricular path they follow once they are on it. Virginia requires all middle schools to provide students with access to an Algebra I course (VBOE, 2009, 8 VAC 20-131-90C).

School divisions can accomplish acceleration of students by compressing the curriculum so that it is taught in a shorter amount of time, or by choosing to skip parts of the curriculum altogether. It is possible to both condense curriculum and skip curriculum, although this tends to happen only with students being accelerated more than one grade level ahead, such as those students who take Algebra I in seventh grade and Geometry in eighth grade.

Figure 14 shows a conceptual framework for acceleration under Virginia's mathematics curriculum. The traditional route shows a student progressing through Math 5 in her fifth grade year, Math 6 in her sixth grader year, and so on until reaching Algebra I during ninth grade which would be her first year of high school. Pathways 1-4 show how the curriculum can be adapted by skipping a year's math content so that the student arrives in Algebra I in eighth grade. Pathways 5-8 show how this can be accomplished by compressing the curriculum into blended courses which consist of more than one grade level of mathematics content. In Pathways 5, 6, and 7, a student would complete two years of math in one of the school years. In Pathways 8 and 9 a student would complete three years of math in two years of school. Depending on the curricular pathway being used, there may be only one or multiple entry points. As with the pathways themselves, school divisions and sometimes even the schools themselves determine their own placement criteria for students.

Figure 14

Curricular Pathways to Algebra I for Virginia Public Schools



Note. Pathways 1-4 show possible curricular pathways using skipped content.
Note. Pathways 5-9 show possible curricular pathways using curriculum compressing.
Note. Griffin (2013)

There is also the consideration of which SOL test a student takes at the end of a school year, particularly if compressing the curriculum has resulted in a blended course of more than one grade level of content. Virginia law (VBOE, 2009, 8 VAC 20-131-30B) limits students to taking one SOL test per subject area per academic year, so regardless of whether compressing the curriculum or skipping were used, the student must miss a final state assessment of one year of mathematics content somewhere along the curricular pathway. This can limit entry points to a curricular pathway depending on which tests a student has already taken. Eighth grade students cannot count double – they must take either the Math 8 SOL test or the Algebra I EOC test. No Child Left Behind requires each student in grades 3-8 to be tested yearly in math and reading – if the student already took and passed the Math 8 test prior to beginning Algebra I but decides to drop out of the Algebra class mid-year then the school will be penalized for the lack of a test score that year.

Virginia also allows parents of middle school students who are attempting high school level coursework to expunge their student's grade at the end of the year according to policies established by the local school board (VBOE, 2009, 8 VAC 20-131-90C). The parents may request expunging for any reason, even if the student has passed the Algebra I EOC test. The student can then repeat Algebra I in ninth grade but will not have to re-take the EOC test.

School divisions are allowed to make their own decisions in setting forth the curricular pathways students can take and the entry points to those pathways. The state does not keep a cumulative record of this, although the information is contained in individual division reports (Bolling, 2013).

Entry Points to Curricular Paths.

There is no way to completely separate placement criteria from curricular pathways. The survey instrument used in this study attempted to determine common placement criteria that are being used by school divisions. SOL scores, grades, diagnostic tests, teacher recommendations, and parent input are all possible indicators for placement.

While SOL scores are consistently tabulated state-wide, unless the placement personnel actually looks at the break-down of a student's score by mathematical strand it is possible to place students in Algebra I who scored well enough on the test as a whole but low in strands emphasized in Algebra (e.g., the sections Patterns, Functions & Algebra and Number & Number Sense). School divisions set their own grading scales (e.g., 10-point, 6-point), and the grades themselves are vulnerable to subjectivity depending on the school and the teaching staff. Diagnostic tests could include nationally-normed instruments, such as the Orleans-Hanna, but might also include readily-available tools such as the Algebra Readiness Diagnostic Test which was not designed to measure aptitude for beginning Algebra I (VDOE, 2009). A locally developed test might also be used which has not been reviewed for validity and reliability. As stated previously, teacher recommendations and parental input are highly subjective and can be unreliable, particularly in regards to equity issues such as race and socio-economic status (Spielhagen, 2006).

Placement criteria would also need to be considered in light of students moving in and out of school districts. Virginia has a large number of military employees and their families, which creates a large number of students moving between districts within the state and from schools outside of Virginia. Placement criteria is not normed between schools or divisions let alone other states, so its use becomes even more subjective when there is no one available who has experience with the data provided. Schools often err on the side of caution rather than placing a student into a more challenging class when the student is already dealing with the stress of moving. At this time there is no single document that indicates placement criteria used by school divisions throughout the state (Bolling, 2013).

Conclusion and Summary

Virginia has a strong educational system which has served as a model for other states. In mathematics, the Virginia Department of Education has incorporated educational research findings into its curricula documents, state assessments, and educational policy decisions. While not formally advocating Algebra I in eighth grade for all students, the Virginia Department of Education has provided a strong curricular framework to ensure all students have access to the necessary pre-requisite content and processing skills. This study attempted to find out how school divisions are using this information to provide educational opportunities and learning for eighth grade students in mathematics.

CHAPTER 3: METHODOLOGY

Chapter Three details this study's methodology. The research design section includes a discussion of study design and the theoretical perspective of the researcher. The research strategy section outlines the methods by which the researcher gained access to information which will be used in this study. The sample section includes a description of the study participants who will be surveyed. The instrumentation section discusses the survey instrument that will be used and its validity and reliability evidence as well as question design. The data collection section describes the procedures that will be used to obtain data for this study, and the data analysis section lays out the methods by which the researcher will analyze the data. Validity and reliability of the study will be discussed under the heading of Trustworthiness and Authenticity. The final section documents how the researcher ensured the safety and ethical trust of the study participants.

Research Questions

This study examined the curricular pathways of students taking Algebra I in the eighth grade in Virginia.

1. At what grade levels do students enter the curricular pathway to take Algebra I as an eighth grader?
2. What placement criteria are considered for a student to take Algebra I as an eighth grader?
3. What is the curricular pathway to taking Algebra I in eighth grade? (That is, is this accomplished by compressing the amount of time spent in teaching the full K-8 mathematics curriculum or by skipping a grade level of mathematics?)

4. To what extent did school divisions change their curricular pathway to Algebra I in eighth grade?
5. What is the relationship between the curricular pathway used and scores on the Virginia Algebra I End-of-Course (EOC) Standards of Learning test?

Research Design

This was a descriptive, trend study which includes correlational components. The descriptive portion was an analysis of curricular pathways that have been and are currently in use by Virginia school divisions. The 2011-2012, 2012-2013, and 2013-2014 school years were analyzed, as these were the years during which the new 2009 *Standards of* Learning were officially tested. This information was not currently collected or analyzed in a single location by the Virginia Department of Education (Bolling, 2013), and the researcher expected to see changes in a school division's curricular pathway policy during this three year period. This information was obtained by administering a survey to Virginia school division mathematics coordinators. Further descriptive analysis resulted from patterns that emerged as to school division locality (rural, urban, or suburban) using demographic information obtained from the Virginia Department of Education.

The correlational aspect of this study was in comparing student scores on the Algebra I EOC test to the curricular pathway used to get them to that point to determine if there was a significant relationship. The independent variable in this study was the curricular pathway chosen to get students to completing Algebra I in eighth grade. The dependent variable was student achievement on the Virginia Standards of Learning Algebra I EOC test. The researcher anticipated that there would at minimum be a distinction between curricular compressing and skipped content pathways, with perhaps even further ranking possible according to the particular courses that were compressed or skipped.

Research Strategy

A survey was administered to math coordinators in all school divisions in Virginia. Responses from the survey were coded to determine curricular pathways used over a three-year span, curricular placement criteria, and additional information concerning students who take Algebra I in eighth grade. School divisions' Algebra I EOC scores from the corresponding school years and demographic data for Virginia school divisions were obtained from the Virginia Department of Education (VDOE.

Research Sample

A list of math coordinators for school divisions in Virginia was provided by the Mathematics Supervisor at the Virginia Department of Education. Math coordinators are the contact person for VDOE concerning mathematics curriculum and assessment decisions made in a particular school division. Most division math coordinators have taught mathematics themselves prior to assuming a more administrative role for the school division, and therefore have mathematical content and pedagogological knowledge to draw on when making policy decisions. Some smaller school divisions may not have a designated math coordinator. Instead the assistant superintendent for instruction may assume the role of curriculum leader in more than one area, or there may be a position which combines areas (e.g., a math and science coordinator).

Limitations and Delimitations

This study was conducted with Virginia school divisions only, and may not be generalizable to other states. Virginia utilizes its own Standards of Learning which are comparable to but not exactly aligned with the Common Core State Standards – Mathematics.

The unit of analysis for this study was at the school division level. Findings of this study may not be applicable to individual students.

As of the time of this study, Virginia does not mandate an algebra-for-all policy at eighth grade, so the majority of Virginia students either self-select or are selected to take Algebra I in eighth grade. This study only applies to the pathways taken by Virginia students to reach Algebra in eighth grade, not sooner. Different pathways, particularly ones which combine compressed and skipped curriculum, are utilized by students taking Algebra I in seventh grade.

This study is limited by a survey response rate of less than 100%. Not all survey respondents had a mathematics background, although it is assumed that they were knowledgeable about the curricular pathways in use for their school division even if they did not fully understand the background rationale. Even though Virginia has standards for mathematics topics by grade level and for Algebra I as the first high school course, individual school divisions determine the delivery of this curriculum. Differences in allotted instructional time and leveling of classes by student ability cannot be fully determined by this study.

Instrumentation

Survey

Prior to taking the survey, participants received a cover letter via email that stated the purpose of the study and asked them to collect data needed to complete the survey prior to commencing it. This allowed participants to be fully prepared to complete the survey in a 15-20 minute time period.

The survey was developed to determine the entry points, placement criteria, and curricular pathways for eighth grade students taking Algebra I. Respondents were also asked if their policy had changed during the time period. Participants were asked to provide information for three separate school years (2011-2012, 2012-2013, and 2013-2014) regarding entry point(s) to curricular pathways and the courses included in the pathways used. Figure 15 on the following page shows the correspondence of research questions to survey questions. Note that as the first four questions of the survey were repeated for three different school year periods, these questions have a designation of *a,b,c* after them to denote the repetition.

Figure 15

Curricular Pathways to Algebra I Survey Questions

Research Question	Relevant Survey Questions
When do students enter the curricular pathway to take Algebra I as an eighth grader?	• Question 1 *a,b,c* for each school year section block. • Respondents had a choice of 4th grade or earlier, 5th grade, 6th grade, or 7th grade. • Respondents chose all that applied
What is the curricular pathway to taking Algebra I in eighth grade? Is this accomplished by compressing the amount of time spent in teaching the full K-8 mathematics curriculum or by skipping a grade level of mathematics?	• Question 2 *a,b,c* for each school year section block. • Respondents chose between curriculum compressing and skipping content. • The survey re-directed to the appropriate match based on their response (Question 3 *a,b,c*. • Question 4 *a,b,c* asked respondents to report the corresponding SOL test taken by students in grade 5, grade 6, and grade 7.
What placement criteria is considered for a student to take Algebra I as an eighth grader?	• Question 5, following the school year sections. • Respondents chose from SOL test scores(s), Benchmark test score(s), Placement test score(s), Classroom grades(s), Teacher recommendation(s), and Parent/Guardian input. • Respondents could also respond that no placement criteria are used because there is open enrollment for Algebra I.
To what extend did Virginia school divisions change their curricular pathways to Algebra I in eighth grade?	• Question 7. • If respondents chose YES, then they were prompted to provide information for each of the three different school years. • If respondents chose NO, they were only prompted for 2013-2014.

Note: Survey created by M.R. Griffin, 2013.

The survey concluded with an area for the respondent to provide any additional insights or comments, and to agree to be contacted by the researcher if needed.

During the administration of the survey, each question appeared on a separate screen. This allowed for better focus by the participant on each individual question and helped avoid possible errors in responding to the question. Participants were able to toggle back and forward in the survey if needed, which allowed the participant to go back to correct mistakes if they were realized later in the process. A progress bar showing the percentage of the survey completed was also included on each page. This had a positive reinforcing effect on participants who could see that they were making progress towards completing the survey.

Validity and Reliability

Validity and reliability of this survey was determined by having a panel of math curriculum experts test the survey prior to its dissemination to state mathematics coordinators. The panel was asked to give feedback to the researcher via a follow-up email to determine their perception of the wording choices, question construction, user-friendliness of the survey, their ability to provide the requested survey information, and an overall rating of the survey. The survey was tested with a representative sample of urban, suburban, and rural school divisions to determine if there was any bias in the construction of the survey. The survey was also piloted by several administrators with no mathematical background

Data Collection

Survey

The researcher used a web-based survey to collect data from administrators in Virginia's school divisions. The survey was developed using the Qualtrics software package and was administered online. Math coordinators were contacted via email with a link to the survey. A copy of the survey is included as Appendix A.

State Assessment Data

The researcher utilized the Virginia SOL Assessment Build-A-Table application from the Virginia Department of Education (VDOE) website to obtain data for each separate school division. Additional data on school division demographics (geographic designation, local funding, etc.) was also utilized from VDOE to further delineate curricular pathway policy decisions. Figure 16 summarizes information that was obtained from the VDOE.

Figure 16

School Division Data – Virginia SOL Assessments

School Division Data – Virginia SOL Assessments
• Total number of students taking the Algebra I EOC test in eighth grade • Percentage of students for each scoring category: Pass Advanced, Pass Proficient, and Fail Basic • Participation rate • Average scaled score on the test • Locality designation (urban, suburban, rural)

Data Analysis

Entry points were analyzed by percentage of school divisions using them. A breakdown of rural, urban, and suburban divisions was included.

Placement criteria were analyzed by type, showing percentages for each type of criteria overall and by subgroup (rural, urban, and suburban). The number of placement criteria used was also tabulated and presented using percentages.

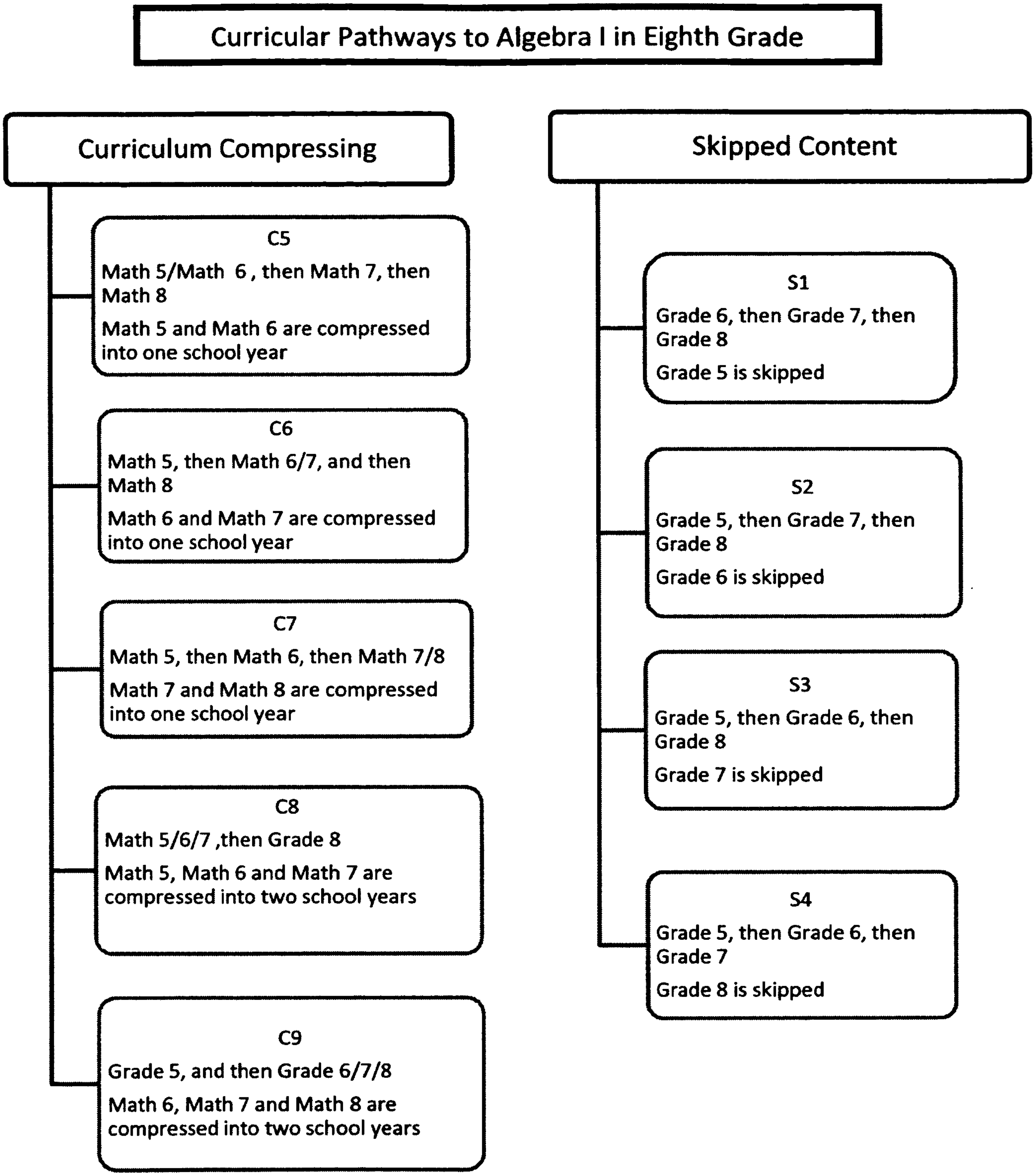
Survey responses regarding the curricular pathway taken for a particular school year were sorted initially into curriculum compressing (coded as C1, C2, C3, C4, and C5) and skipping content (coded as S1, S2, S3, and S4). From these two main branches, the courses used in the curriculum pathway were determined based on survey responses that identify which courses were compressed or skipped.

There were four possible skipped content pathways with each omitting one year of Virginia SOL mathematics curriculum (Math 5, Math 6, Math 7, or Math 8). The curriculum compressing pathways differ not only in the amount of time used to compress the curriculum, but also in the amount of curriculum compressed. Three possibilities resulted from compressing two years of math curriculum into a single year of instruction (Math 5/6, Math 6/7, or Math 7/8). The other two possibilities resulted from compressing three years of curriculum into two years of instructional time, causing a carryover of grade level content from one school year to the next (Math 5/6/7 or Math 6/7/8). The possible outcomes are shown in Figure 18 on the next page.

Chi square tests were used to determine the relationship between the curricular pathways (C1, C2, C3, C4, C5, S1, S2, S3, or S4) and SOL score outcomes (Pass Advanced, Pass Proficient, or Fail Basic). Pearson coefficients were used to correlate the data.

Many of the data analysis decisions were made once the data was gathered to see if there was significant representation in all possible curricular pathways. The researcher expected that there could be curricular pathway differences based on geographic designation (rural, urban, or suburban).

Figure 17:



Griffin, 2013.

Trustworthiness and Authenticity

Content validity for this study was established by expert review. Five individuals with expertise in mathematics curriculum at the secondary level (Grades 6-12) reviewed the survey and provided feedback to the researcher. The Virginia Department of Education Coordinator for Mathematics also examined the survey provided feedback.

Ethical Considerations

All participants were informed via cover letter and at the commencement of the survey that their participation was entirely voluntary and their information would be kept confidential. Participants typed in their name to agree to terms and conditions on the first survey page. School divisions were not identifiable in the presentation of findings. An executive summary of the findings will be shared with participants.

Chapter 4 – Data Analysis

Restatement of Research Questions

This study examined the curricular pathways of students taking Algebra I in the eighth grade in Virginia. To that end, the following research addressed:

1. At what grade level do students enter the curricular pathway to take Algebra I as an eighth grader?
2. What placement criteria are considered for a student to take Algebra I as an eighth grader?
3. What is the curricular pathway to taking Algebra I in eighth grade? (That is, is this accomplished by compressing the amount of time spent in teaching the full K-8 mathematics curriculum or by skipping a grade level of mathematics?)
4. To what extent did school divisions change their curricular pathway to Algebra I in eighth grade?
5. Is there a relationship between the curricular pathways used and scores on the Virginia Algebra I End-of-Course (EOC) Standards of Learning test?

Background

This was a descriptive, trend study which also included a correlational component. The descriptive portion of the study focused on entry points to curricular pathways leading to Algebra I and the placement criteria considered for enrollment in Algebra I as an eighth grader. In addition the study analyzed the curricular pathways that have been and are currently in use by Virginia school divisions, including any policy changes school divisions made in regards to these pathways. The 2011-2012, 2012-

2013, and 2013-2014 school years were analyzed, as these are the years during which the new 2009 *Standards of* Learning were officially tested. The information was obtained by administering a survey to Virginia school division personnel as identified by the Virginia Department of Education (VDOE). Data for school population were attained from the Weldon Cooper Center for Public Service (2014). Data for school locale classification were obtained from VDOE and the National Center for Educational Statistics (2014).

For the correlational aspect of this study, school division pass rates on the Algebra I EOC test were correlated with the curricular pathways used during the 2011-2012 and the 2012-2013 school years to determine if there was a relationship.

In addition to the quantitative responses requested, survey respondents were also given a comment section to allow for free-response of additional information they felt might be beneficial to the study. Information from this qualitative section is threaded throughout the discussion in Chapter 5.

Data Collection and Sources

The William and Mary Protection of Human Subjects Committee approved this study on January 17, 2014. This study was completed between January and March, 2014. The target population was Virginia school divisions. A total of 132 school divisions in Virginia received requests for information via a web-based survey. This accounted for all Virginia school divisions which serve a general population. The Department of Juvenile Justice, Middle Peninsula Regional Special Education Program, and Virginia School for the Deaf and Blind were omitted as these schools offer alternative educational settings outside of a general classroom mode.

The study included a web-based survey which asked about a school division's policies for having eighth grade students complete Algebra I in middle school. The survey was piloted with the state mathematics coordinator, mathematics-specific administrators and teachers in K-12 education, and administrators who do not have math as an area of expertise, in order to assure clarity of wording, format, and questioning techniques. The survey was disseminated to all respondents on January 24, 2014, using a personalized email which included a link to the survey. A follow-up reminder was sent to school divisions who had not responded as of February 16, 2014, which consisted of a personalized email added to the original message that was previously sent. Several respondents forwarded the email to a member of their staff who they felt could better provide the information requested in the survey, which was noted when respondents gave their name, school division, and position when completing the survey.

School Division Representation

The overall response rate for this study was 70%. A total of 92 school divisions responded to the request for information, with 88 school divisions completing the online survey. Two school divisions declined the request for information due to division policies. Two other school divisions had technical difficulties with the survey and were sent a Word-version of the survey, but did not return the survey to the researcher. One school division duplicated efforts in the web-based survey by having two separate people respond. The incomplete response from this school division was deleted. The end result was 87 data sources for analysis, representing 66% of Virginia school divisions.

Survey respondents were asked to identify their school division as rural, urban, or suburban, as seen in Table 4. The number and percentages of schools surveyed closely matches those of Virginia as a whole. With regards to rural, urban, and suburban designations, this sample if representative of the state of Virginia. The survey respondents also provided a well-diversified geographical representation for Virginia, as seen in Table 5.

Table 4

Virginia School Divisions by Rural, Urban, and Suburban Classification

Virginia School Divisions by Classification				
	All Virginia School Divisions		Surveyed School Divisions	
	Count	Percentages	Count*	Percentages
Rural	92	69.7%	57	65.5%
Urban	15	11.4%	14	16.1%
Suburban	25	18.9%	16	18.4%
	132	100%	87	100%

*Note: Classification self-provided by survey respondents.

Table 5

Virginia School Divisions by Geographic Classification According to Superintendent Districts

Virginia School Divisions by Geographic Classification According to Superintendent Districts			
		n/Total	Percentage of Total
Region 1	Central Virginia	10/15	67%
Region 2	Tidewater	10/15	67%
Region 3	Northern Neck	12/17	71%
Region 4	Northern Virginia	15/19	79%
Region 5	Valley	16/20	80%
Region 6	Western Virginia	7/15	47%
Region 7	Southwest	14/19	74%
Region 8	Southside	4/12	33%

The subgroups of rural, urban, and suburban school division were analyzed by student population, based on the School Age Population Estimates for Virginia's School Divisions (Weldon Cooper Center for Public Service, 2012), as seen in Table 6. Overall this study represents school division policies affecting 1,030,554 out of 1,574,906 students, which is 65% of Virginia's school age population.

Participating school divisions were also analyzed using the 2014-2016 Composite Index of Local Ability-to-Pay (VDOE, 2013), as seen in Table 7.

Table 6

Virginia School Age Population Analysis by Participating Rural, Urban, and Suburban School Divisions

Virginia School Age Population Analysis by Participating Rural, Urban, and Suburban School Divisions		
	Population Range of School Age Students	Average Number of Students in Division
Rural	610 to 15,467	4,585
Urban	1,724 to 39,315	11,365
Suburban	748 to 223,161	39,104

Table 7

Local Ability-to-Pay Index by Participating Rural, Urban and Suburban School Divisions

Local Ability-to-Pay Index by Participating Rural, Urban, and Suburban School Divisions		
	Range	Average
Rural	.1756 to .8000	.3948
Urban	.2221 to .8000	.3583
Suburban	.3101 to .8000	.4662

Identifying Information

Survey respondents were asked to enter their name, position and school division. The respondents were evenly divided between general administration (superintendent, director of instruction, principal, etc.) and math-specific leadership roles (mathematics coordinator, math specialist, math teacher, etc.). Survey respondents were also asked to declare their secondary mathematics background knowledge.

Course sequence policies

Before determining which school divisions had changed their policies, it was first necessary to determine if the division had a policy in place. Survey respondents were questioned about their division policy and/or standard practice to put students on a curricular pathway to take Algebra I in eighth grade. From a total of 87 school divisions, 76% (66 divisions) had a policy in place and 24% (20 divisions) did not have a set policy.

Of the 20 school divisions without an Algebra policy, 15 identified themselves as rural districts, four identified as urban districts, and one identified as suburban. These school divisions represented seven of the eight geographic regions.

Entry Points

At what grade level do students enter the curricular pathway to take Algebra I as an eighth grader? Entry points to the curricular pathway varied as well, with all possibilities represented. Some divisions have only one grade level that is the entry point, while others have two or more, which resulted in a total of eight possible classifications. Table 8 shows the breakdown of entry points.

Table 8

Entry Points to a Curricular Pathway for Algebra I in Eighth Grade

Entry Points to a Curricular Pathway for Algebra I in Eighth Grade	
	Percentage of school divisions
4^{th} Grade or Lower	6%
5^{th} Grade	9%
6^{th} Grade	28%
7^{th} Grade	35%
5^{th} or 6^{th} Grade	3%
6^{th} or 7^{th} Grade	14%
Any grade – no set entry point	5%

A single entry point at seventh grade, closely followed by a single entry point at sixth grade, were the most frequently reported entry points, accounting for 63% of the school divisions that responded to the survey. Combined with 14% of students who enter a pathway at either sixth or seventh grade, it appears that most students do not enter a curricular pathway to Algebra I in eighth grade until they are in middle school.

The analysis for rural, urban, and suburban subgroups is shown in Table 9 and shows that across these classifications most students are entering a curricular pathway at the middle school level. The data for rural school divisions represents in all possible entry point categories, unlike the urban and suburban districts which do not use either the category "fourth grade or lower" or "fifth or sixth grade" as entry points.

The entry of students onto a curricular pathway to Algebra I in middle school at fourth grade or lower most frequently occurs for students who are accelerating more than one year so that they take Algebra I in seventh grade. There may have been a misunderstanding on the part of the respondents who chose this possibility.

Suburban school divisions only allow entry at the middle school level, with the exception of one school division which has no set entry point. All three classifications contain divisions which allow entry to curricular pathways at any grade with no set entry point.

Table 9

Entry Points by Rural, Urban, and Suburban School Divisions

Entry Points by Rural, Urban, and Suburban School Divisions			
	Rural	Urban	Suburban
4th Grade or Lower	9.5%	0.0%	0.0%
5th Grade	9.5%	30.0%	0.0%
6th Grade	21.4%	30.0%	40.0%
7th Grade	38.1%	10.0%	33.3%
5th or 6th Grade	2.4%	0.0%	0.0%
6th or 7th Grade	11.9%	20.0%	20.0%
Any grade – no set entry point	8.6%	10.0%	6.7%

Placement Criteria

School divisions determine which students to put on the pathway to Algebra I in eighth grade using a variety of placement criteria. The survey included the descriptors seen in Table 10 below, and survey respondents were allowed to choose all categories that applied to their school division. For clarity, the criteria are listed in descending response percentages rather than in the order they were presented in the survey. There were no school divisions that used only one criterion for Algebra I placement. Table 11 shows the breakdown of school divisions by number of criteria used.

Table 10

Placement Criteria for Algebra I Used by Virginia School Divisions

Placement Criteria for Algebra I Used by Virginia School Divisions	
SOL Score(s)	90%
Classroom Grade(s)	82%
Teacher Recommendation(s)	82%
Parent/Guardian Input	52%
Benchmark Score(s)	46%
Placement Score(s)	30%
No Criteria Used	7%

There were no school divisions that used only one criterion for Algebra I placement. Table 11 shows the breakdown of school divisions by number of criteria used. The majority of schools used either four or five criteria when making placement decisions.

Table 11

Number of Criteria Used to Determine Algebra Pathway Placement

Number of Criteria Used To Determine Algebra Placement	
Six criteria used	15%
Five criteria used	28%
Four criteria used	36%
Three criteria used	12%
Two criteria used	3%
No criteria used	7%

An analysis by rural, urban and suburban subgroups is included in Tables 12 and 13. All three subgroups follow the whole group trend for use of SOL scores, classroom grades, teacher recommendations, and parent/guardian input. Suburban school divisions are more likely to use placement test scores over benchmark test scores. Across all three subgroups, school divisions were likely to use four or more criteria to determine placement.

Table 12

Analysis of Placement Criteria for Algebra I by Subgroups

Analysis of Placement Criteria for Algebra I by Subgroups			
	Rural	Urban	Suburban
SOL Score(s)	100.0%	80.0%	80.0%
Classroom Grade(s)	95.2%	70.0%	80.0%
Teacher Recommendation(s)	97.6%	70.0%	73.3%
Parent/Guardian Input	66.7%	60.0%	46.7%
Benchmark Score(s)	61.9%	50.0%	20.0%
Placement Score(s)	40.5%	50.0%	33.3%
No Criteria Used	7.1%	10.0%	20.0%

Suburban school divisions scored lower than rural or urban in using parent/guardian input. Research has shown that in schools with a high socio-economic base, administrators routinely accept parents' requests for math placement (Spielhagen, 2006; Useem, 1991). As suburban school divisions are well funded in comparison to rural and urban schools (see Chapter 3, Table 7) this data contradicts the literature.

Suburban schools also are least likely to use a placement test compared to rural or urban schools. Giving a placement test costs time and money, and while suburban school divisions are well funded, they are also highly populated compared to rural and urban divisions (see Chapter 3, Table 6). The time and expense involved in giving a placement test may factor into this statistic.

At 20%, suburban divisions also are more likely than rural or urban school divisions to not use criteria for placement. Population again may play a role in this, as a larger population makes it easier for a school division to absorb student failures which would impact school accountability ratings. The larger populations may also make it easier for schools to provide options for students who select into an Algebra I class but find they are not being successful. The scope of this study does not allow for definite answers.

Table 13

Analysis of Number of Placement Criteria Used by Subgroups

Analysis of Placement Criteria for Algebra I by Subgroups			
	Rural	Urban	Suburban
Six criteria used	14.6%	40.0%	0.0%
Five criteria used	24.4%	20.0%	33.3%
Four criteria used	46.3%	10.0%	40.0%
Three criteria used	9.8%	20.0%	6.7%
Two criteria used	2.4%	0.0%	12.5%
No criteria used	2.4%	10.0%	6.7%

In the comments section of the survey, some respondents provided comments that conflict with the placement criteria they reported, resulting in a conflict between set policy and the practice carried out in schools. Chapter 5 provides an in-depth discussion of this dichotomy.

Curriculum Delivery

In Virginia, Algebra I is designated as the first high school credit-earning mathematics class. In elementary and middle school, students progress from Math 3 through Math 8 prior to entering high school. In order to take Algebra I in the eighth grade, a student must either have completed a compressed curriculum which teaches more material in less time, or followed a skipped curriculum in which the content of a grade level is omitted from the curriculum. Nine curricular pathways were determined for use in this survey. Pathways S1, S2, S3, and S4 represented skipped curriculum, and Pathways C5, C6, C7, C8, C9, and C10 represented compressed curriculum. Table 14 shows the trends over the past three school years.

Table 14

Comparison of Compressed Curriculum Policy versus Skipped Curriculum Policy

A Comparison of Compressed Curriculum Policy versus Skipped Curriculum Policy			
	2011-2012	2012-2013	2013-2014
Compressed curriculum	52%	54%	57%
Skipped curriculum	48%	46%	43%

The results show that school divisions are evenly divided between using curriculum compressing and skipping curriculum in 2011-2012, but the overall trend is moving towards using compressed curriculum, with a 14 percentage point difference between the two methods for 2013-2014.

Skipped curriculum.

Both the skipped curriculum choice and the compressed curriculum choice contain subgroups according to pathway distinctions. Table 11 shows the variations for skipping curriculum for each of the three school years.

Table 15

Virginia School Divisions Utilizing Skipped Curriculum Pathways

Virginia School Divisions Utilizing Skipped Curriculum Pathways			
	2011-2012	2012-2013	2013-2014
S1: Skip Math 5	0%	0%	0%
S2: Skip Math 6	19%	13%	10%
S3: Skip Math 7	13%	13%	14%
S4: Skip Math 8	68%	74%	76%

None of the school divisions participating chose to skip Math 5 (Pathway 1). Over the three year period, there was a definite move away from skipping Math 6 (Pathway 2). Skipping Math 7 (Pathway 3) held steady. Skipping Math 8 (Pathway 4) is the favored choice for most of these school divisions, and it appears that schools switched from skipping Math 6 to skipping Math 8 when they made a change.

Compressed curriculum.

For a compressed curricular pathway to Algebra I in eighth grade, school divisions may choose to compress two years of math into one year or three years of math into two years. Table 16 shows the possible compressed pathways with percentages of use by school year.

Table 16

Virginia School Divisions Utilizing Compressed Curriculum Pathways

Virginia School Divisions Utilizing Compressed Curriculum Pathways			
	2011-2012	2012-2013	2013-2014
C5: Math 5/6, then Math 7, then Math 8	3%	6%	8%
C6: Math 5, then Math 6/7, then Math 8	22%	19%	18%
C7: Math 5, then Math 6, then Math 7/8	14%	11%	8%
C8:Math 5/6/7, then Math 8 (3 years into 2 years)	0%	0%	0%
C 9: Math 5, then Math 6/7/8 (3 years into 2 years)	47%	50%	53%
C10: Math5/6/7/8 (4 years into 3 years)	14%	14%	13%

No school divisions utilized Pathway 8, which condenses Math 6, Math 7, and Math 8 to be taught during Grade 5 and Grade 6. It is possible that this is not considered a viable option due to logistics. There are usually a number of elementary feeder schools into a middle school, and it would be difficult to ensure continuity with a curriculum that straddles the transition to middle school.

A tenth pathway (C10) also came to light during this research in which some school divisions are using a curricular pathway that compresses four years of math into three years. Of the five school divisions on this pathway, three are urban districts and two are rural. No school divisions opted into or out of C10 during the three year period.

An analysis of pathways chosen by subgroups gives a clearer picture of the differences of curricular pathways used by rural, urban, and suburban divisions.

Rural School Divisions.

Rural school divisions showed the greatest variance among curricular pathways for all three years studied. For 2011-2012 and 2012-2013, slightly more than half of the rural school divisions used skipped curriculum (52.3%). By 2013-2014, the balance is even (49.9% to 50.1%) between skipped or compressed curriculum. This variance could be due to several factors, such as teaching capacity, the physical logistics of moving students between school buildings, or the lack of a dedicated mathematics coordinator to make decisions. The data collected for this survey was insufficient to provide a certain answer.

Rural divisions utilizing skipped curriculum remained consistent in their split between pathways of skipping Math 6 (S2) and skipping Math 7 (S3), with the pathway of skipping Math 8 (S4) the predominant choice for skipped curriculum. Compressed curriculum made a definite shift away from pathways C6 (Math 5/6 compressed) and C7 (compress Math 7/8) towards pathway C9 (compress Math 6/7/8 into two years). This shift shows a movement away from compressing two years of curriculum into a single year of instruction and towards using two years to teach three years of curriculum. Neither the S1 (skip Math 5) nor the C8 (compress Math 5/6/7) pathways were used by any rural divisions.

Table 17 shows the curricular pathways used by rural school divisions in this study.

Table 17

Analysis of Curricular Pathways Chosen by Rural School Divisions

Analysis of Curricular Pathways Chosen by Rural School Divisions			
Pathway	2011-2012	2012-2013	2013-2014
S1: Skip Math 5	0.0%	0.0%	0.0%
S2: Skip Math 6	9.5%	7.1%	7.1%
S3: Skip Math 7	9.5%	9.5%	9.5%
S4: Skip Math 8	33.3%	35.7%	33.3%
C5: Math 5/6, then Math 7, then Math 8	2.4%	4.8%	4.8%
C6: Math 5, then Math 6/7, then Math 8	9.5%	7.1%	7.1%
C7: Math 5, then Math 6, then Math 7/8	11.9%	9.5%	7.1%
C8: Math 5/6/7, then Math 8 (compress 3 years into 2 years	0.0%	0.0%	0.0%
C9: Math 5, then Math 6/7/8 (compress 3 years into 2 years)	19.0%	21.4%	26.2%
C10: Math5/6/7/8 (compress4 years into 3 years)	4.8%	4.8%	4.8%

Urban school divisions.

Urban school divisions remained the most consistent in pathway choices over the three year period studied. The only skipped curriculum pathway used by urban school divisions in this study is S4, which skips Math 8. Pathways C6 (compress Math 6/7) and

C9 (compress Math6/7/8) were used for compressed curriculum during the first two years studied. . Neither the S1 nor the C8 pathways were used by any urban divisions.

Urban school divisions were evenly divided between skipped or compressed curriculum until the 2013-2014 year, when one division made the decision to change from using the S4 skipped curriculum pathway to the C5 (compress Math 5/6) compressed curriculum path. This causes the overall percentage to shift in favor of compressed curriculum (80%).

Table 18 provides the data analysis for urban school divisions.

Table 18

Analysis of Curricular Pathways Chosen by Urban School Divisions

Analysis of Curricular Pathways Chosen by Urban School Divisions			
Pathway	2011-2012	2012-2013	2013-2014
S1: Skip Math 5	0.0%	0.0%	0.0%
S2: Skip Math 6	0.0%	0.0%	0.0%
S3: Skip Math 7	0.0%	0.0%	0.0%
S4: Skip Math 8	30.0%	30.0%	20.0%
C5: Math 5/6, then Math 7, then Math 8	0.0%	0.0%	10.0%
C6: Math 5, then Math 6/7, then Math 8	10.0%	10.0%	10.0%
C7: Math 5, then Math 6, then Math 7/8	0.0%	0.0%	0.0%
C8: Math 5/6/7, then Math 8 (compress 3 years into 2 years	0.0%	0.0%	0.0%
C9: Math 5, then Math 6/7/8 (compress 3 years into 2 years)	30.0%	30.0%	30.0%
C10: Math5/6/7/8 (compress4 years into 3 years)	30.0%	30.0%	30.0%

Suburban school divisions.

Suburban school divisions more heavily favored using compressed curriculum pathways for all three years studied, with slightly more than 70% of suburban schools using compressed versus skipped curriculum. Neither the S1 nor the C8 pathways were used by any suburban divisions.

Compressed curricular pathways remained consistently divided between C6 and C9, which was the preferred pathway of the two. Variation occurred in the skipped curriculum choices. The use of Pathway S2 which skips Math 6 decreases steadily and disappears by the 2013-2014 school year, with those school divisions having moved to using a S4 path. By 2013-2014, only the S4 pathway is being used in suburban schools.

The data analysis for suburban school divisions is shown in Table 19.

Table 19

Analysis of Curricular Pathways Chosen by Suburban School Divisions

Analysis of Curricular Pathways Chosen by Suburban School Divisions			
Pathway	2011-2012	2012-2013	2013-2014
S1: Skip Math 5	0.0%	0.0%	0.0%
S2: Skip Math 6	14.3%	7.1%	0.0%
S3: Skip Math 7	0.0%	0.0%	0.0%
S4: Skip Math 8	14.3%	21.4%	28.6%
C5: Math 5/6, then Math 7, then Math 8	0.0%	0.0%	0.0%
C6: Math 5, then Math 6/7, then Math 8	21.4%	21.4%	21.4%
C7: Math 5, then Math 6, then Math 7/8	0.0%	0.0%	0.0%
C8: Math 5/6/7, then Math 8 (compress 3 years into 2 years	0.0%	0.0%	0.0%
C9: Math 5, then Math 6/7/8 (compress 3 years into 2 years)	50.0%	50.0%	50.0%
C10: Math5/6/7/8 (compress4 years into 3 years)	0.0%	0.0%	0.0%

SOL Testing

While the curricular pathways that students take leading to Algebra in eighth grade vary, so do the summative SOL tests they take prior to reaching eighth grade. Four testing patterns emerged from the survey responses, as seen in Table 19

Table 19

SOL Testing Structure for Grades 5, 6, and 7

SOL Testing Structure for Grades 5, 6, and 7			
	2011-2012	2012-2013	2013-2014
Math 5, then Math 6, and then Math 7	57%	61%	59%
Math 5, then Math 6, and then Math 8	22%	20%	19%
Math 5, then Math 7 and then Math 8	18%	16%	16%
Math 6, then Math 7 and then Math 8	3%	3%	6%

The data shows that the combination of Math 5, Math 6, and Math 7 tests is the most widely used testing pattern and has been so for all three of the years studied. This corresponds to the high percentage of school divisions that skip Math 8, which necessitates the Math 5/6/7 testing pattern. The remaining test patterns correlate to divisions who used compressed curriculum or skipped a grade level other than Math 8.

Policy Changes

Of the 67 school divisions with a set Algebra policy, nine school divisions made changes in policy during the school years studied, resulting in 13% of school divisions making policy changes. Five of these divisions made changes within either a compressed or skipped curriculum policy, and four made changes between skipped and compressed curriculum policies. These changes will be discussed in further detail in Chapter 5.

Curricular Pathways and SOL Scores

For the Algebra I EOC assessment, a score of 500 – 600 is considered Passed Advanced, a score of 400 - 499 is considered Passed Proficient, and a score of 200-399 is considered Failed Basic. A score of 400 on this test corresponds to correctly answering 50% of the questions given on the assessment.

Tables 20 and 21 show the curricular pathways used during the 2011-12 and 2012-2013 school years, with a brief description for that school year following the corresponding table. Schools with no policies (n=20) were included in this initial data analysis.

Table 20

Curricular Pathways and SOL Scores: 2011-2012 School Year

Curricular Pathway and SOL Scores 2011-2012 School Year			
Curricular Pathway Used	Number of School Divisions	Average overall pass rate	Average scaled score
S1: Skip Math 5	0	---	---
S2: Skip Math 6	5	83.5%	430.35
S3: Skip Math 7	4	87.2%	430.54
S4: Skip Math 8	21	90.7%	437.43
C5: Condense Math 5/6, then Math 7, then Math 8	3	80.1%	421.68
C6: Math 5, then condense Math 6/7, then Math 8	6	89.5%	439.70
C7: Math 5, then Math 6, then condense Math 7/8	4	86.6%	433.82
C8: Compress Math 5/6/7 in two years, then Math 8	0	---	---
C9: Math 5, then compress Math 6/7/8 in two years	19	91.7%	438.93
C10: Compress Math 5/6/7/8 into three years	5	85.5%	437.87
Divisions with no set policy for a curricular pathway	20*	87.8%	431.66

* Two divisions had $n<3$ participants, so no pass rate was reported by the state. The average scaled score is included. One school division included in this group did not have any students take the Algebra I test during 2011-12.

Data Analysis for 2011-2012 SOL Test Results.

The Pearson's *r* correlation for this data showed a negligible relationship (all values less than .20) and no significance for Curricular Pathway to the 2012 Pass Rate, 2012 Pass Advanced, 2012 Fail, and 2012 Scaled Score.

Pathway S1 (Skip Math 5) and Pathway C8 Compress Math 5/6/7 in two years, then Math 8) were not utilized by any school divisions in this survey. Pathways S4 (skip Math 8) and C9 (Math 5, then compress Math 6/7/8 in two years) dominated the curricular pathways for 2011-12. The remaining pathways (S2, S3, C5, C6, C7, and C10) had even dispersal of school divisions among them.

Pass rates ranged from a low of 80.1% for the C5 pathway to a high of 91.7% for the C9 path. All three divisions in the C5 pathway are rural, while the C9 contains 19 school divisions which represent all three subgroups. School divisions with no set policy faired quite well with an 87.8% average pass rate.

Average scaled scores had a range of 18.02 points, from the low of 421.68 for C5 to a high of 439.70 for C6. The average scaled scores for all groups were close to the mean of 433.55, with a standard deviation of 5.42.

Table 21

Curricular Pathways and SOL Scores: 2012-2013 School Year

Curricular Pathway and SOL Scores 2012-13 School Year			
Curricular Pathway Used	Number of School Divisions	Average overall pass rate	Average scaled score
S 1: Skip Math 5	0	---	---
S 2: Skip Math 6	6	85.8%	442.00
S 3: Skip Math 7	4	67.6%	424.41
S 4: Skip Math 8	19	85.0%	434.55
C 5: Condense Math 5/6, then Math 7, then Math 8	2	44.4%	399.78
C 6: Math 5, then condense Math 6/7, then Math 8	6	91.1%	450.14
C 7: Math 5, then Math 6, then condense Math 7/8	5	70.5%	433.32
C8: Compress Math 5/6/7 in two years, then Math 8	0	---	---
C 9: Math 5, then compress Math 6/7/8 in two years	18	86.2%	438.79
C 10: Compress Math 5/6/7/8 into three years	5	87.0%	441.73
Divisions with no set policy for a curricular pathway	20*	74.9%	428.53

* Two divisions had $n<3$ participants. Average scaled score is included, but not pass rate.

Data Analysis for the 2012-2013 SOL Test Results.

The Pearson's *r* correlation for Curricular Pathway and 2013 Pass Rate was .206, which shows a weak positive correlation (.206), but was not significant ($p=.058$). The correlation of Curricular Pathway and 2013 Fail Rate showed a weak negative correlation

(-.203) but was also not significant (p=.062). Separate correlations run for Curricular Pathway to 2013 Pass Advanced and 2013 Scaled Score showed a negligible relationship and no significance. Pathway S1 (Skip Math 5) and Pathway C8 (Compress Math 5/6/7 in two years, then Math 8) were not utilized by any school divisions in this survey. Pathways S4 (skip Math 8) and C9 (Math 5, then compress Math 6/7/8 in two years) continued to dominate the curricular pathways for 2012-13. The remaining pathways (S2, S3, C5, C6, C7, and C10) had even dispersal of school divisions among them.

Average overall pass rates ranged from 44.4% to 91.1%, and rates fell across most pathways. C5 (compress Math 5/6) was the lowest scoring pathway, which also lost a high-scoring division in 2012-2013, lowering it to only two members. C7 (compress Math 7/8) gained the high scoring division that left C5, but any boost from this was offset by a school division with a pass rate that dropped 54.2%.

C6 (compress math 6/7) had the highest average overall pass rate and average scale for 2012-2013. While the number of members remained the same, there was movement into and out of the C6 pathway in 2012-2013, although in both cases the divisions had average scaled scores in the 90% range.

Average scaled scores showed a larger range this year of 50.36 points, from a low of 399.78 in C5 to a high of 450.14 for C6, maintaining their position from 2011-2012. The mean average scaled score was 432.58 with a standard deviation of 13.55.

School divisions with no set policy experienced a lower average pass rate of 74.9% but retained an average scaled score close to the mean.

Comparisons of 2011-2012 and 2012-2013 Data.

Table 22 compares the pass rates by curricular pathway for 2011-2012 and 2012-2013.

Pathway C5 (compress Math 5/6) saw the largest decrease in pass rates. This was a sparsely populated group, and the drop can be completely attributed to a high-scoring school division utilizing another pathway in 2012-2013. Interestingly, this same division is returning to the C5 pathway in 2013-2014 as they saw their scores drop with the change they made. As such, the 2013-2014 pass rate will likely return to the previous level.

Pathways S3 (skip Math 7) and C7 (compress Math 7/8) also experienced large pass rate losses from 2012 to 2013 at -19.6% and -16.1%. In 2012-2013, C7 gained the high scoring division that left C5, but any boost from this was offset by a school division with a pass rate that dropped 54.19%. Once again, each of these sparsely populated groups suffered from a single school division in the group that had pass rates below 30% in 2013. The two most populated pathways (S4 and C9) both experienced a drop of about -5.5% from 2012 to 2013.

Table 22

Comparison of 2011-2012 and 2012-2013 SOL Pass Rates by Curricular Pathway

Comparison of 2011-2012 and 2012-2013 SOL Pass Rates by Curricular Pathway			
Curricular Pathway Used	2011-2012 Average overall pass rate	2012-2013 Average overall pass rate	Change
S 1: Skip Math 5	----	---	---
S 2: Skip Math 6	83.5% *n=5*	85.8% *n=6*	+2.3%
S 3: Skip Math 7	87.2% *n=4*	67.6% *n=4*	- 19.6%
S 4: Skip Math 8	90.7% *n=21*	85.0% *n=19*	- 5.7%
C 5: Compress Math 5/6, then Math 7, then Math 8	80.1% *n=3*	44.5% *n=2*	- 35.6%
C 6: Math 5, then compress Math 6/7, then Math 8	89.5% *n=6*	91.1% *n=6*	+ 1.6%
C 7: Math 5, then Math 6, then compress Math 7/8	86.6% *n=4*	70.5% *n=5*	- 16.1%
C8: Compress Math 5/6/7 in two years, then Math 8	---	---	---
C 9: Math 5, then compress Math 6/7/8 in two years	91.7% *n=19*	86.2% *n=18*	- 5.5%
C 10: Compress Math 5/6/7/8 into three years	85.5% *n=5*	87.0% *n=5*	+ 1.5%
Divisions with no set policy for a curricular pathway	87.8% *n=17*[a]	74.9% *n=18*[b]	-12.9%

a 20 school divisions identified as having no set policy for a curricular pathway. Two of these school divisions had fewer than three students take the Algebra I test in eighth grade and did not have pass rates reported by VDOE. In addition another division did not have any students take the Algebra I EOC test in 2011-2012.

b 20 school divisions identified as having no set policy for a curricular pathway; however, two of these divisions had fewer than three students take the Algebra I test in eighth grade for 2012-2013.

The Relationship between Curricular Pathways and SOL Pass Rates

To determine if there was a relationship between the curricular pathway used and SOL pass rates, the data were cross-tabulated for each school year. Table 23 and Table 24 present the data and Chi Square tests for the 2011-2012 school year.

Table 23

Cross Tabulation of 2012 SOL Pass Rates and Curricular Pathways

Cross Tabulation of 2012 SOL Pass Rates and Curricular Pathways						
	50-60%	60-70%	70-80%	80-90%	90-100%	TOTAL
S2: Skip Math 6 Count % of S2	0 0.0%	0 0.0%	1 16.7%	2 33.3%	3 50.0%	6 100%
S3: Skip Math 7 Count % of S3	0 0.0%	0 0.0%	1 25.0%	1 25.0%	2 50.0%	4 100%
S4: Skip Math 8 Count % of S4	0 0.0%	1 5.0%	3 15.0%	3 15.0%	13 65.0%	20 100%
C5: Math 5/6, then Math 7, then Math 8 Count % of C5	1 100%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 100%
C6: Math 5, then Math 6/7, then Math 8 Count % of C6	0 0.0%	0 0.0%	0 0.0%	4 50.0%	4 50.0%	8 100%
C7: Math 5, then Math 6, then Math 7/8 Count % of C7	0 0.0%	0 0.0%	2 40.0%	0 0.0%	3 60.0%	5 100%
C9: Math 5, then Math 6/7/8 in 2 years Count % of C9	0 0.0%	0 0.0%	4 23.5%	2 11.8%	11 64.7%	17 100%
C10: Math 5/6/7/8 in 3 years Count % of C10	0 0.0%	1 20.0%	1 20.0%	0 0.0%	3 60.0%	5 100%
Total Count Total Percentages	1 1.5%	1 1.5%	12 18.5%	12 18.5%	39 60.0%	65 100%

Table 24

Chi-Square Tests for 2011-2012 SOL Pass Rates and Pathways

Chi-Square Tests for 2011-2012 SOL Pass Rates and Pathways			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	83.557	28	.000
Likelihood Ratio	27.781	28	.476
Linear-by-linear association	.007	1	.935
N of Valid Cases	66		

Based on a confidence level of $p<.05$, the data shows a relationship between curricular pathways and the 2012 SOL pass rates with a value of p = .000. However, the statistical zeros which appear in Table 23 are likely what has caused the significant Chi square findings, thus making them insignificant.

To be certain of this, the researcher chose to combine pathways S2 through S4 into the variable called "skipped curriculum" and pathways C5-10 into the variable "compressed curriculum" to determine if there was a relationship between these two larger groups and the 2012 SOL pass rate. These results are seen in Table 25.

Table 25

Cross-tabulation of Skipped or Compressed Curricular Pathways to 2012 Pass Rates

Cross-tabulation of Skipped or Compressed Curricular Pathways to 2012 Pass Rates						
	SOL Pass Rates					
	50-60%	60-70%	70-80%	80-90%	90-100%	TOTAL
Skipped Curriculum						
Count	0	1	5	6	18	30
% within Skipped	0.0%	3.3%	16.7%	20.0%	60.0%	100%
% within 2012 Pass Rate	0.0%	50.0%	41.7%	50.0%	46.2%	45.5%
% of total	0.0%	1.5%	7.6%	9.1%	27.3%	45.5%
Compressed Curriculum						
Count	1	1	7	6	21	36
% within Compressed	2.8%	2.8%	19.4%	16.7%	58.3%	100%
% within 2012 Pass Rate	100%	50.0%	58.3%	50.0%	53.8%	54.5%
% of total	1.5%	1.5%	10.6%	9.1%	31.8%	54.5%
Totals						
Count	1	2	12	12	39	66
% within Skip/Compress	1.5%	3.0%	18.2%	18.2%	59.1%	100%
% within 2012 Pass Rate	100%	100%	100%	100%	100%	100%
% of total	1.5%	3.0%	18.2%	18.2%	59.1%	100%

At p=.906, this analysis did not show statistical significance for choosing skipped or compressed curriculum in relation to the 2012 SOL pass rates.

The introduction of increased rigor and technology-enhanced questions to the 2011-12 Algebra I EOC test caused an implementation dip in pass rates for schools across Virginia (VDOE, 2012). Most schools are striving to regain their past success in this arena. The researcher chose to re-group the 2012 pass rates into -90% and a 90-100% to further analyze the relationship between curricular pathways and the pass rate. These results are reported in Table 26.

Table 26

Skipped/Compressed Curriculum and 2012 Optimal Pass Rates

Skipped/Compressed Curriculum and 2012 Optimal Pass Rates			
	50-90%	90-100%	TOTAL
Skipped Curriculum	12	18	30
% within Skipped	40.0%	60.0%	100%
% within 2012 Pass Rate	44.4%	46.2%	45.5%
% of total	18.2%	27.3%	45.5%
Compressed Curriculum	15	21	36
% within Compressed	41.7%	58.3%	100%
% within 2012 Pass Rate	55.6%	53.8%	54.5%
% of total	22.7%	31.8%	54.5%
Totals	27	39	66
% within Skip/Compress	40.9%	59.1%	100%
% within 2012 Pass Rate	100%	100%	100%
% of total	40.9%	59.1%	100%

This analysis returned a p=.891 value which is not statistically significant. From the table we can also see that either skipped or compressed curricular pathways yield about the same percentages of the total in both the lower pass rate and the optimal pass rate ranges. Pass rates for the 2012-2013 school year showed much greater variation than the previous year.

Tables 27 and 28 show the cross-tabulation of curricular pathways and 2013 pass rates. As was seen with the 2012 Pass Rates, the 2013 Pass Rates initially show a significant relationship between pathways and pass rates of p=.003.

Once again the researcher created two larger sub-groups of skipped and compressed curriculum to determine if there was a relationship, as seen in Table 23. As was the case for the previous year, the *p* value rose (.335), and there was no statistically significant relationship shown.

Tables 27

Cross Tabulation of 2013 SOL Pass Rates and Curricular Pathways

Cross Tabulation of 2013 SOL Pass Rates and Curricular Pathways										
	10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	90-100%	TOTAL
S2: Skip Math 6 Count % of S2	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 25.0%	1 25.0%	2 50.0%	4 100%
S3: Skip Math 7 Count % of S3	0 0.0%	1 25.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 50.0%	0 0.0%	1 25.0%	4 100%
S4: Skip Math 8 Count % of S4	0 0.0%	0 0.0%	0 0.0%	1 4.3%	1 4.3%	1 4.3%	7 30.5%	3 13.0%	10 43.6%	23 100%
C5: Math 5/6, then Math 7, then Math 8 Count % of C5	0 0.0%	0 0.0%	1 50.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 50.0%	2 100%
C6: Math 5, then Math 6/7, then Math 8 Count % of C6	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 14.3%	0 0.0%	1 14.3%	3 42.8%	2 28.6%	7 100%
C7: Math 5, then Math 6, then Math 7/8 Count % of C7	1 25.0%	0 0.0%	0 0.0%	0 0.0%	1 25.0%	0 0.0%	0 0.0%	1 25.0%	1 25.0%	4 100%
C9: Math 5, then Math 6/7/8 in 2 years Count % of C9	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4 22.2%	6 33.3%	8 44.5%	18 100%
C10: Math 5/6/7/8 in 3 years Count % of C10	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 20.0%	0 0.0%	1 20.0%	3 60.0%	5 100%
Total Count Total Percentage	1 1.5%	1 1.5%	1 1.5%	1 1.5%	3 4.5%	2 3.0%	15 22.4%	15 22.4%	28 41.%7	67 100%

Table 28

Chi-Square Tests for 2012-2013Pass Rates and Pathways

Chi-Square Tests for 2012-2013			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	89.445	56	.003
Likelihood Ratio	44.561	56	.864
Linear-by-linear association	1.260	1	.262
N of Valid Cases	67		

Table 29

Cross Tabulation of 2013 SOL Pass Rates and Curricular Pathways

Cross Tabulation of 2013 SOL Pass Rates and Curricular Pathways										
	10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	90-100%	TOTAL
Skipped Curriculum										
Count	0	1	0	1	1	1	10	4	13	31
% within Skipped	0.0%	3.2%	0.0%	3.2%	3.2%	3.2%	32.3%	12.9%	41.9%	100%
% within 2012 Pass Rate	0.0%	100%	0.0%	100%	33.3%	50.0%	66.7%	26.7%	46.4%	46.3%
% of total	0.0%	1.5%	0.0%	1.5%	1.5%	1.5%	14.9%	6.0%	19.4%	46.3%
Compressed Curriculum										
Count	1	0	1	0	2	1	5	11	15	36
% within Compressed	2.8%	0.0%	2.8%	0.0%	5.6%	2.8%	13.9%	30.6%	41.7%	100%
% within 2012 Pass Rate	100%	0.0%	100%	0.0%	66.7%	50.0%	33.3%	73.3%	53.6%	53.7%
% of total	1.5%	0.0%	1.5%	0.0%	3.0%	1.5%	7.5%	16.4%	22.4%	53.7%
Totals										
Count	1	1	1	1	3	2	15	15	28	67
% within Skip/Compress	1.5%	1.5%	1.5%	1.5%	4.5%	3.0%	22.4%	22.4%	41.8%	100%
% within 2012 Pass Rate	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
% of total	1.5%	1.5%	1.5%	1.5%	4.5%	3.0%	22.4%	22.4%	41.8%	100%

The range of 2013 pass rates lent itself to a three-way division of pass rates data rather than the two-way split used for 2012, due to the appearance of less than 50% pass rates. The pass rates were divided into 50%, 50-90%, and 90-100% bands, as shown in Table 30. Once again the there is no statistically significant relationship with a *p* value of .987.

Table 30

Skipped/Compressed Curriculum and 2013 Optimal Pass Rates

Skipped/Compressed Curriculum and 2013 Optimal Pass Rates				
	Below 50%	50-90%	90-100%	TOTAL
Skipped Curriculum				
Count	2	16	13	31
% within Skipped	6.5%	51.6%	41.9%	100%
% within 2012 Pass Rate	50.0%	45.7%	46.4%	46.3%
% of total	3.0%	23.9%	19.4%	46.3%
Compressed Curriculum				
Count	2	19	15	36
% within Compressed	5.6%	52.8%	41.7%	100%
% within 2012 Pass Rate	50.0%	54.3%	53.6%	53.7%
% of total	3.0%	28.4%	22.4%	53.7%
Totals				
Count	4	35	28	67
% within Skip/Compress	6.0%	52.2%	41.8%	100%
% within 2012 Pass Rate	100%	100%	100%	100%
% of total	6.0%	52.2%	41.8%	100%

Summary of Research Findings

- The majority of students enter a curricular pathway to Algebra I in eighth grade when they reach middle school.

- SOL scores are the most frequently used placement criterion in use, followed by classroom grades and teacher input. 79% of schools use four or more criteria when determining placement on a curricular pathway to Algebra I.
- School divisions are about evenly divided between using a skipped curriculum or a compacted curriculum. The trend seems to be moving away from skipped curriculum towards compressed curriculum based on the past three years' data.
- Two possible pathways (S1 and C8) are not used by any school divisions. One compressed curriculum pathway (C10) was added based on the results of the survey.
- Pathways S4 (Skip Math 8) and C9 (Math 5, then Math 6/7/8, compressing 3 years into 2) were the most populated pathways in this study.
- Four SOL testing structures were identified based on the results of the survey. Most students will take the Math 5, Math 6, and Math 7 SOL tests before beginning Algebra I, thus skipping the Math 8 SOL test.
- 13% of the school divisions made policy changes during the three year period studied. Five changes were within either a skipped or compressed curriculum, and four were between the two.
- When school divisions with no set Algebra policy were included in a correlation analysis of SOL pass rates to curricular pathways, both years studied (2012 and 2013) showed only weak correlations for overall pass rates and no statistical significance. These relationships remained the same for comparisons of Pass Advanced rates, Fail Basic rates, and Average Scaled Scores.
-

- Cross-tabulation of SOL Pass rates to Curricular Pathways excluding no-policy school divisions displayed statistical significance for both 2012 and 2013, showing that there is a relationship between curricular pathways and SOL pass rates. Further analysis by compacting skipped and compressed pathways into two groups did not show statistical significance, nor did an attempt to split the SOL pass rates into broader ranges.
- Initially there was a statistically significant relationship between curricular pathways and SOL pass rates when evaluated for $p<.05$ of $p=.000$ for 2012 and $p = .003$ for 2013 using the original breakdown by individual pathways. Further analysis comparing skipped versus compressed pathways revealed no clear advantage to either skipped or compressed curriculum.

In addition to the quantitative data represented in this chapter, many survey respondents took the opportunity to include comments related to this research in a free-response question included in the survey. This qualitative data will be used in Chapter 5 to provide more depth and understanding in the discussion of this research.

Chapter 5: Discussion, Implications, and Recommendations

Introduction

Having students start Algebra I in eighth grade rather than waiting until high school continues to be a national debate (Loveless, 2008). Many school districts throughout the country have moved towards placing more students in eighth grade Algebra I (NCES, 2012). While this provides opportunities for students who did not formerly have access to higher level mathematics class in middle school (Spielhagen, 2006; Mulkey, Catsambis, Steelman, & Crain, 2005; Gamoran & Hannigan, 2000), it has also created a set of problems of its own in regards to whether or not students are truly prepared to move forward rapidly in the mathematics curriculum (Loveless, 2013).

Chapter 5 includes a discussion of the results of this study in light of the relevant literature. While primarily a quantitative study, the inclusion of an open-ended question during the survey process allowed respondents to provide information that they felt was applicable to this research topic. This produced a response from 40 of the 67 school divisions with policies, and provided the researcher considerable insights into how these division leaders are seeking to provide the best possible structure for their students. This information is woven into the discussion topics of Chapter 5 and is provided in Appendix C.

It should be noted once again that the unit of analysis for this study is at the division level and may not be generalized to individual students. Implications for practice are imbedded within each section rather than being discussed separately at the end.

Purpose of the Study

The purpose of this study was to determine the entry points, placement criteria, and curricular pathways currently in use by Virginia school divisions that allow eighth grade students to take Algebra I. Additionally, these pathways were analyzed with SOL test data to determine if there were correlations between the pathway used and scores on the Algebra I EOC assessment. Specifically the researcher sought to answer the following research questions:

1. At what grade level do students enter the curricular pathway to take Algebra I as an eighth grader?
2. What placement criteria are considered for a student to take Algebra I as an eighth grader?
3. What is the curricular pathway to taking Algebra I in eighth grade? (That is, is this accomplished by compressing the amount of time spent in teaching the full K-8 mathematics curriculum or by skipping a grade level of mathematics?)
4. To what extent did school divisions change their curricular pathway to Algebra I in eighth grade?
5. Is there a relationship between the curricular pathway used and scores on the Virginia Algebra I End-of-Course (EOC) Standards of Learning test?

Division Policy

In collecting data for this study, the initial branching question that respondents encountered was whether their division has a set policy or practice for placing students on a curricular pathway to completing Algebra I in eighth grade. This section of Chapter 5 will discuss the possible ramifications of operating without a policy as well as the challenges faced when changing or implementing a new policy.

Non-Policy Divisions

The majority of school divisions that responded to this survey have a division-level policy which enables students to take Algebra I in eighth grade. Included in this policy are the entry points to the curricular pathway, placement criteria required, and the sequence of mathematics coursework leading to Algebra I. Of the 87 schools responding to this study, 67 of them (77%) have a policy in place. These 67 school divisions became the main focus of the data collected for this study, but several points concerning non-policy divisions bear mention.

The 20 school divisions who identified as not having a policy encompassed rural, urban, and suburban divisions and also varied in size from small rural schools to multi-school urban districts. These school divisions were not directly asked for their reasoning, but the variety of type of divisions suggests that these reasons would be diverse as well. While a follow-up study would be needed to pinpoint the actual reasons, some of the differences between rural, urban, and suburban school divisions can shed light on the topic.

For example, a review of public documents revealed that one of the urban divisions who responded uses a self-select policy for eighth grade Algebra which allows students to enroll without having to meet placement criteria. While school divisions want the best success rate for all students, a larger urban or suburban district is more able to absorb a higher failure rate on the Algebra I EOC test and still make adequate progress for accountability. A larger school division will usually have the capacity to provide options for students who find the need to back off from completing Algebra I in middle school, allowing for not only entry to but exit from an early Algebra track.

Some of the smaller rural school divisions operate only one middle school and one high school for the entire division, so policy begins and ends at the physical school building rather than at the district office. However, when placement decisions are left up to building level administration, there is less likely to be continuity across time within a division. With a more personal attachment to students and staff, principals may be likely to look towards parent requests or teacher input instead of using data for decision making.

The SOL pass rate data for no-policy divisions did turn up some concerns. From 2012 to 2013, the SOL pass rate for no-policy schools dropped by an average of 13%, in spite of the addition of a 100% pass rate to the 2013 data (see notes for Chapter 4, Table 22). Of the 18 school divisions with reported pass rates, two divisions remained at approximately the same rate for both years. Three divisions improved their pass rates slightly, with the largest gain being 6.09%. The 12 remaining divisions all had declining pass rates, ranging from a modest increase of 2.2% to a decrease of 63.3%. Six of these divisions had pass rates below 60% for 2013. These divisions were well-diversified in terms of size and locale, indicating that there is not a trend based on rural, urban, or suburban designation.

An implementation dip was expected for 2012, but the continuance and magnitude of decreasing pass rates should be a concern. Research has shown that algebra-for-all policies can cause increased failure rates (Stoelina & Lynn, 2013; Murray, 2012). Further study would be needed to determine if that is the case here in Virginia.

Changing Policy

Of the 67 school divisions with a set Algebra policy, nine school divisions made changes in policy during the school years studied, resulting in 13% of school divisions making policy changes.

Five of these divisions made changes within either a compressed or skipped policy. In three of these cases, the school division made a policy change for one year (2012-2013) and is now reverting back to the 2011-2012 policy for the current year of 2013-2014. These cases are represented by one rural and one suburban division using compressed curriculum and one rural division using a skipped curriculum. The remaining two school divisions are moving to a new policy for 2013-2014 but staying within either a skipped or compressed framework. These divisions represent a rural division using compressed curriculum and a suburban division using skipped curriculum. Both divisions are moving towards the most highly populated pathways of S4 (skip Math 8) and C9 (Math 6/7/8 in two years).

Four school divisions made changes between skipped and compressed curriculum policies. An urban and a rural division chose to switch from a skipped curriculum to a compressed curriculum. The other two divisions are both rural, and both are reverting back to a previous policy for 2013-2014 after switching to a new policy in 2012-2013. One of these is following a skipped-compressed-skipped move with the other doing the opposite. These two school divisions are reverting to the highly populated S4 and C9 pathways.

Looking at the SOL pass rates for 2012 and 2013, seven of the nine school divisions had pass rates that dropped an average of 8.2% from 2011-2012 to 2012-2013. The other two both continued at a 100% pass rate. Four-fifths of the reverting school divisions experienced a drop, and three-fourths of the new policy ones did. The schools that reverted had a greater average drop at 9.4% than did the new policy schools at 6.6%. The move towards a new policy can be rationalized by a division analyzing the changes in the standards and testing rigor and deciding to move in a new direction to bring more success. So why did some school divisions make a change after only one year? The initial change may have been a response to the new standards, as many school divisions were shocked at the rigor of the new SOL tests. It could have been triggered by the purchase of next textbooks or changes in instructional staff. We do not know if these divisions are grasping at straws by using a reactionary approach to SOL scores, with change being a constant for these divisions rather than an anomaly. Making policy changes this quickly does not seem prudent, but perhaps that is only in contrast to the extended time period we seem to endure without change in the world of K-12 education where many school divisions remain resistant to change altogether. It will be interesting to see how the 2013-2014 scores are for school divisions who are reverting back to a previously attempted pathway.

Entry Points

Students enter middle school with the same course sequencing background, as the study showed that no school divisions are skipping Math 5 as a curricular pathway for Algebra I in eighth grade. This means that students are expected to have completed through Math 5 when they begin sixth grade.

This study showed that the majority of Virginia students are entering the track to complete Algebra I in eighth grade when they reach middle school, with seventh grade (35%) closely followed by sixth grade (28%) as the predominant entry points. This matches the research which shows that most students enter a track to complete Algebra I in middle school by either middle school or late elementary school (Stiff, Johnson, & Akos, 2011).

Only 22% of school divisions allow for multiple entry points, even though research has shown that rigidity of tracking is a concern, particularly in middle school compared to high school (Lucas, 2001). One suburban division commented on the need to provide multiple ways for students to "jump track" and get to Algebra in eighth grade yet ensure that they have all the necessary instruction for success. Rural school divisions provided earlier entry points than urban or suburban divisions and seemed to show more flexibility in entry points as well. This may be a factor of placement decisions happening more often at the building level.

We do not know how school divisions handle students from other divisions who move into their district and were on a different pathway, or who move from another state. In an ever increasingly transient society, inflexible entry points can be a problem for these students. The move towards a national curriculum provided by the Common Core State Standards – Mathematics (CCSS-M) may provide some relief in this area. At this time Virginia has no plans to adopt CCSS-M, and review of mathematics standards is set to begin soon for the 2016 revision. The state does also not appear to be moving towards a state-wide policy regarding this matter either. There is policy addressing students transferring into a division at the high school level and the impact on verified credits for graduation (VDOE, 2014b), but the issue is not addressed at the middle school level at all.

Perhaps as important as entry points to a pathway to Algebra I in eighth grade is the possibility of exit points if students are not thriving. Two school divisions with open enrollment policies commented that they assess all students at the end of the first six weeks of school specifically for this purpose. If a student is feeling overwhelmed or not making adequate progress, the course placement can be adjusted. One rural division using a skipped curriculum policy commented that they use this method as well, with the pathway chosen (S4 – Skip Math 8) allowing for a place for these students to go if they opt out of Algebra I as an eighth grader. Maturity levels in middle school are wide-ranging, and a policy that acknowledges this by providing multiple entry and exit points makes sense. Readiness for Algebra I in eighth grade hinges on more than just the math content previously learned, as will be discussed in the next section on placement criteria.

Placement Criteria

Research has shown that math placement is highly dependent on standardized tests, teacher input, and parental contracts and power (Useem, 1992). This study reaffirmed this research, as Virginia school divisions use SOL test scores, classroom grades and teacher input, and parental input above placement tests when determining eligibility for a curricular pathway to Algebra I in middle school.

The placement criteria considered for this study included SOL tests, benchmark tests, placement tests, classroom grades, teacher recommendations, and parent/guardian input. These criteria were deliberately presented in the order stated above which represents a hierarchy moving from state to division to school to home. The use of multiple criteria tends to follow this pattern as well, with most school divisions using criteria from four or more sources to inform placement decisions, a pattern that was consistent across rural, urban, and suburban school divisions.

Well-intending administrators put policies in place to help students progress along an academic course of study; however, sometimes these policies are faulty in spite of their good intentions. Placement criteria is viewed as a necessary and integral part of helping students along the pathway to Algebra I by 93% of the school divisions in this study, with 79% using four or more criteria in the process. The use of multiple criteria is an admirable practice, showing a desire to take a holistic view of a student rather than using a single determinant of fate. Unfortunately, validity and reliability issues keep this practice from accomplishing the goal of accurately determining a child's readiness for Algebra. Consider the most frequently used criterion, SOL scores.

State Level Criteria: SOL Scores

In order to accurately determine a student's readiness for learning Algebra, you would need to use a diagnostic test with sub-scales to determine aptitude rather than focusing on previously learned information. If part of a larger assessment, you would need to determine which particular portions of the test are applicable to your needs. Cutoff scores would be pre-determined and consistently used by all parties. This is not what is happening in Virginia.

SOL scores represent a look at a student's progress in mathematics at the state level. SOL tests are being used as the chief criterion for eligibility, yet this is not their intended purpose. The SOL test is curriculum-based assessment created to determine mastery of specific content taught within a course (VDOE, 2009a). The test is created using a blueprint that determines the percent of questions from each strand, with a sampling of specific content standards represented within the strands.

School divisions look at a student's overall SOL score to determine placement. The cutoff score for Algebra is random, with no real bearing to an accurate assessment of algebra capability. The difference between a score of 410 and 450 could result from many things other than algebra readiness, such as better ability on the probability questions of the test or better performance on technology-enhanced items. The score difference has no real meaning other than for what it is intended – to show what percentage of the past year's mathematics content a student has learned. There is no way to determine an accurate qualifying score for Algebra because the test is not measuring what is needed.

When a school division uses the overall scaled score used for placement, they do not know a student's strengths or weaknesses in particular areas, so decisions may be made incorrectly. A student could pass the SOL test but not have performed well in areas deemed critical to Algebra I success, such as operations with fractions, proportional reasoning, or setting up and using expressions, equations, or inequalities (NCTM, 2006; NMAP, 2008). Administrators would need to break down the students' scores by strand to get an accurate indication of strengths and weaknesses, yet even this can be faulty. Multiple forms of the test given in a specific year match percentage of questions required for each strand according to the testing blueprint (VDOE, 2009b), but the rigor of the questions within that strand may vary because rigor is an overall measure of the test not specifically of a strand (VDOE, 2013c). Virginia considers this adequate for its purposes, which is to assess a student's understanding of the math learned in that school year. For the purpose of placement criteria, this is not a reliable data source.

So why do school divisions use SOL tests scores to determine placement? First, the SOL test is considered a professionally-created test that has been thoroughly tested by the state for validity and reliability. True, a standardized test is less susceptible to reliability issues, but the problem here is that the test is not measuring what is needed. Secondly, because all students take the SOL tests, they are seen as a viable instrument for comparing students. This is true, if you are comparing them on math content learned but not for aptitude for Algebra. Thirdly, the SOL scores are readily available because all students take it. Even if a student moves from another Virginia school division, the admitting personnel can easily look up the student's scores. And lastly one of the most important reasons, the SOL test is a freebie! School divisions are required to give the test anyway, so there are no additional costs of time or money associated with it which would likely occur if a placement test was given.

This study is limited by having only formally asked if SOL scores are used as placement criteria, but comments from respondents shed some light on what is happening in practice. School divisions may use one or more SOL test scores to determine placement. The cut score varies from division to division. One urban school division commented that it also uses a student's reading SOL scores in addition to the mathematics scores when determining placement.

SOL test are the most widely used criterion for Algebra placement. Only two school divisions out of the 62 school divisions that use placement criteria do not use SOL scores. The data suggests that not only are SOL scores used as placement criteria, but they are also most likely the gatekeeper to consideration of any other criteria in use. If a student does not make the division's set SOL cut score, he/she will not be considered for Algebra placement.

Division Level Criteria: Benchmark Tests and Placement Tests

Forty-six percent of the school divisions rely on benchmark test results as placement criteria for eighth grade Algebra. A benchmark tests is a division-level assessment given each marking period to assess student learning during that period and possibly previously that year if it is cumulative. A benchmark test can give a clearer picture of mastery of a specific topic, and this is usually easier to tease out of the data than it would be with an SOL test, which may explain the wide use of benchmark tests. However, the fidelity of the instrument comes into play once again. The benchmark test, like the SOL test, is used to measure progress in learning during that school year, not aptitude for coming math topics.

Unlike the SOL test, which at least is uniform throughout the state, the benchmark test can arise from multiple sources. Questions may be pulled from a commercial program or written by the math coordinator or math teachers. There is no way to know if the questions have been tested for reliability and validity. The number of questions per topic can vary widely. Math concepts which are critical to success in Algebra may not have been assessed in a benchmark test which is being used to determine Algebra placement. As is the case with the SOL test, benchmark tests are not a valid and reliable placement criteria for Algebra.

A placement test differs from a benchmark tests in that it is designed to measure aptitude rather than previous content knowledge. Placement tests may be given to an entire student body or only to select students. A student may have needed to meet other pre-determined placement criteria before being offered the placement test. Bias in who is given a placement test occurs frequently due to teacher and parent input (Spielhagen, 2006; Hoffer, 1992).

The placement test may be a well-tested commercial product such as the Orleans-Hanna Test. Some divisions may just hand the student a released copy of an SOL test and ask him/her to complete it, using an instrument which is not measuring the intended outcome. In other cases the test may have been developed by the math coordinator or teachers but has not undergone any testing for reliability or validity. Four schools commented that they use the Algebra Readiness Diagnostic Test (ARDT) which is provided by the Virginia Department of Education. While it has the word "algebra" in its title, the test is designed to assess strengths and weaknesses for grade level content and strands. School divisions are specifically cautioned by the state that it is a diagnostic tool not a tool for Algebra placement (VDOE, 2014). As with the SOL test, this is an easily accessible, inexpensive option for schools, so it is often put into use.

Of all the placement criteria used, a good placement test would provide the most accurate data point for Algebra placement, yet only 30% of school divisions attempt to use one. One rural school commented that they have given up using a division-wide placement test with fifth graders due to increased costs. Two divisions in the survey are looking to use a universal screening tool such as the Scholastic Math Inventory (SMI) starting in elementary school and continuing into middle school to better place students.

School Based Criteria: Classroom Grades and Teacher Recommendations

Classroom grades and teacher recommendations are used by 82% of the school divisions, second only to the SOL test as placement criteria. Both of these categories represent a picture of the student in light of school behavior and achievement, reflecting a student's day-to-day levels rather than a one-time snapshot that is provided by the state and division level criteria. Judging by the number of school divisions using grades and teacher recommendations, this is a highly valued part of the placement process.

Like the SOL test, classroom grades are a measure of a student's mastery of content knowledge. A classroom grade provides a composite view of a student's achievement in a mathematics classroom, with components of tests, quizzes, homework, and class work and participation entering into a weighted percentage formula to arrive at a single measurement point. Unlike the SOL test, classroom grades are a highly subjective measure which cannot usually be generalized beyond a single school due to validity, reliability, and fidelity issues. There is no way of knowing if common assessments are used by all schools or even by teachers within a school. The way an assessment is graded, such as no credit versus partial credit, also comes into play. And of course the quality of teaching varies from teacher to teacher as well. While the grades may be reliable within one teacher's classes, comparisons with other teachers would not be reliable.

A classroom grade reflects not only on the student who earns the grade but on how the teacher assigning the grade has chosen the composition of the grade. The majority of teachers create their own quizzes and tests, and the teacher's assessment literacy can have a strong affect on a student's grades because of this. Two teachers within the same school may use very different assessments for the same concepts they both taught, even if the pacing and content of the instruction were identical. Assessments may be unbalanced proportionally to the intended learning outcomes for a unit. Quizzes and tests may not match the cognitive level needed at that grade level's standards, aiming too high or too low. The choice of how to grade the assessment may also cause differences based on the determination of possible points per question and the decision to give or withhold partial credit for answers.

As is the case with the SOL test, the classroom grade used to determine placement may mask deficiencies in areas critical to Algebra I success. Multiple units of study are taught during a grading period and over the course of a school year, so a quarterly grade, semester grade, or final grade will not necessarily reflect strengths and weaknesses in particular areas. The classroom grade is a compilation of homework and classwork grades as well as assessments. These grades may have a strong basis in work effort and participation, which are definitely traits to consider, but which may also artificially inflate or deflate a true measure of mathematical competency.

Most Virginia school divisions rely on teacher recommendations for placement, particularly in rural areas where almost 98% of school divisions use them as part of their placement criteria. Most teachers take the giving of student recommendations very seriously; seeking to make sure their students are going to be in a place where they will be most successful in their next math class. A teacher views a request for placement recommendations as administration's faith in his/her knowledge as a professional educator. Because of this, a teacher recommendation will seek to provide more depth of understanding about a student than the assignment of a numerical grade (Spielhagen, 2006).

Comments on maturity, organizational skills, and problem-solving skills could serve as insightful knowledge of a student's cognitive and processing skills. A teacher has insight into which students are regularly absent, those who come to class prepared daily, and which students grasp new concepts quickly or need more time to process new material. A teacher knows who pays attention in class, who passes notes and socializes, and which student is shy and needs to be approached because he won't ask for help. A rural school division mentions their success in offering eighth grade Algebra to students "who demonstrate good student skills, conceptual understanding, problem solving, and fact fluency." A teacher recommendation is able to provide insight into these areas based on his/her daily interaction with a student.

Unfortunately, there can also be a negative aspect to using teacher recommendations. Classroom behavior, race, and socio-economic status can cause either intentional or unintentional bias during the recommendation process (Walston & McCarroll, 2010). If a student's behavior does not match the teacher's expectations, that student may not be recommended even if he or she is ready for Algebra from a mathematical standpoint. Conversely, a teacher may recommend a student who is well-behaved in class, believing that this will mean success in an advanced math class. Students with IEPs are often passed over due to teacher perceptions of ability (Faulkner, Crossland, & Stiff, 2013), with teachers believing that the intensified pace and content of Algebra may be too much for these students. Two rural divisions in this study spoke to issues with teachers' belief systems conflicting with the ability of some students to have

Algebra I success in middle school. While a teacher's recommendations may be helpful, they can also keep some students out of Algebra I middle school or be overly optimistic for others.

As is the case with classroom grades, fidelity issues can also lower the reliability of teacher recommendations. Does the school division use a formal collection instrument, or do recommendations stem from a conversation with administrators or other math teachers? This study did not delve into the specifics of collection methods used, but as with any assessment the mode of collection should be consistent and reliable.

Home Based Criteria: Parent/Guardian Input

Parent input is used by 52% of the school divisions surveyed, with rural and urban divisions utilizing it at a higher rate than suburban divisions. Parent input is used more often than the division-level criteria of benchmark or placement tests. While students learn Algebra while in attendance at school, administration may feel that parent input holds importance in making sure the student will be supported at home too.

Based on comments received in this study, parent input is a major source of stress and frustration for Virginia school divisions, which mirrors the research. Most students put into Algebra I in middle school for non-academic reasons end up there due to parent input (Spielhagen, 2008; Mulkey, Catsambis, Steelman, & Crain, 2005), and placement in a middle school Algebra class is seen as a status symbol by many parents (Useem, 1991). Math classes that provide compressed curriculum may be labeled "honors," lending them an sense of superiority to which parents may ascribe.

Parents may push their children too quickly down the mathematics pipeline without thinking about the long-term developmental needs of their child. This is often the case with siblings, where an older child did well taking Algebra I in eighth grade and the parent expects the younger brothers or sisters to follow in his footsteps. A rural division commented that "some parents push their children too quickly without understanding the long term developmental needs of their child." Another rural division stated that "in many cases math has become a competition for community status." As Algebra in middle school has become available to more students, some parents worry about the makeup of those classes. Another rural division commented that "many of our parents want their children taking Algebra I in seventh grade," which reflects the position of Algebra I as a status symbol for parents and students alike.

Conversely, what about the child whose parent does not take an interest in education and the child is not seen as a viable candidate for Algebra I. In a case of racial or gender-biased decisions by administration (Spielhagen, 2006), parent input may make the difference in getting the child on the best mathematical pathway.

Parental input is an emotional as well as skill-based criterion, and as such is the most subjective of the entire placement criteria considered. Unless a parent regularly sits in a classroom to observe his/her child, the input is based only on what is happening outside of the school day and on student-perceptions of what happens during the school day. Parent input can create an emotionally-charged situation for teachers and administrators, particularly when policy becomes guidelines.

Placement Decisions: Policy versus Guidelines

In a best-case scenario, the placement decision would be made based on multiple valid and reliable criteria which have been analyzed by a person well-versed in mathematics education. However, decisions are often made that go against division policy, even by the people who set the policy in place.

A division with an open enrollment policy may use placement criteria to give parents and students a recommendation for placement, knowing that the final decision lies in their hands. When parents or students choose to go against these recommendations, the result can be a frustrating experience for the student, parent, and teacher. A suburban division with open enrollment policy commented that "they do not always agree and select a more rigorous class than recommended. This has been a problem for students, teachers, and counselors. If or when the class becomes too difficult for the students, both teacher and parents become frustrated at why the student is not successful." As discussed previously, a school division may or may not have a place for this student to go at the point. Depending on the curricular pathways available at the school, the student may be left with no choice but to finish out the year in an Algebra class in which he/she struggles, missing out on the possibility to build greater math confidence and ability before high school. Schools using the Math 5, Math 6, Math 7 SOL testing sequence are at least able to have students move into a Math 8 course and still meet testing requirements.

When teachers and math specialists have provided placement criteria that are ignored, frustration ensues. One mathematics coordinator commented that "much time has been spent creating the division curriculum pathway at students. At times administrators make exceptions for a student(s) without consulting data or the division math specialist. Hasty decisions have usually backfired." People who collected the placement data are frustrated that their work is not valued and that a student is most likely not being placed in the best academic setting.

Placement criteria that are ignored rather than used also open up issues of validity and reliability of a division's policy. There may be a perception problem on the part of administrators who are actually enacting a open-enrollment policy but trying to make it look standardized by collecting and giving placement recommendations. Perhaps the placement criteria are outdated and are no longer accurately measuring what is really needed to make a decision about Algebra placement. Policy that is frequently being ignored means that either there is a problem with the placement criteria itself or with the fidelity of implementing it.

Curricular Pathways

In order to take Algebra I in eighth grade, students have moved through the sequence of mathematic courses at a more rapid rate. Compressing the course content to teach more content in less time, or skipping some content considered non-critical to success are the two methods used to meet this goal.

This study showed that school divisions in Virginia are almost evenly split between using skipped or compressed curriculum. Even though the last three years have shown a trend away from skipped towards compressed pathways, more than 40% of school divisions are currently using a skipped curriculum. Rural school divisions showed the greatest variety in curricular pathways offered, while urban divisions were the most restricted.

In K-12 education, mathematics is a well-defined curriculum, with the learning of one skill sequentially leading to the learning of the next, particularly at the elementary school level. You will not find discussion as to whether adding and subtracting should be taught before or after multiplying and dividing because one skill is essential to mastering the next. As the curriculum begins to branch into more specific topics at the middle school level, the sequencing of curriculum is not as clear cut. The structuring of a curricular pathway has more options and is less intuitive than it was in earlier grades.

As seen in the literature review, learning mathematics is much more than simply memorizing procedures and rules to solve a given combination of numbers and variables. Students must simultaneously develop conceptual understanding, fluency with processes, and problem-solving logic. Developmentally, students in middle school are moving from the concrete operational to the formal operational stage (Piaget, 1972). Algebra I requires the logical use of symbols and deductive reasoning to work through complex problems (Siegler, 2003), and many students are just not ready for this.

The comments given in this study shed light on the implementation of curricular pathways beyond the quantitative labeling used on the survey questions. While the study delineates between skipped and compressed curricular pathways, in practice hybridization is occurring. This section will consider how curricular pathways are followed and implemented leading up to Algebra I in eighth grade, and how the Algebra I curriculum is delivered in the middle school.

Implementing a Curricular Pathway: Getting to Algebra

Teaching more material in less time creates a time crunch. Some school divisions utilize a longer math period to provide enough time for content to be taught. According to the comments, 80 and 90 minute blocks of math daily in sixth and seventh grade are used to provide ample instructional time in divisions using compressed curriculum. A rural division is using informal blending of curriculum in fourth and fifth grade, providing some compressed curriculum to better help teacher identify students who may need to be placed on an Algebra I track once they reach middle school.

Leveled classes are also used, especially with compressed curriculum that teaches more content in less time. Sixth grade or seventh grade math classes may be labeled "honors" to indicate this distinction.

Content gaps happen, and school divisions are worried about them. Gaps can cause difficulties for students in future classes and may also lower pass rates and average scaled scores on the SOL test. Even though school divisions are using a skipped curricular pathway to Algebra I, they may be supplementing the curriculum with parts of the course they have chosen to skip to avoid knowledge gaps. These gaps may be filled prior to entering Algebra I or once in the Algebra I classroom.

School divisions using skipped curriculum pathways may compensate for the material omitted by frontloading it into other classes. A division or school may incorporate some skills from Math 8 into a Math 7 class without feeling the need to include all material from Math 8. Three school divisions (two suburban, one urban) use summer academies to teach Math 8 content to students who are moving directly from Math 7 to Algebra I. Three other school divisions (two rural, one urban) infuse Math 8 concepts into the Algebra I curriculum when it is taught in eighth grade.

Implementing a Curriculum: Algebra I in Middle School

Tom Loveless asserts in his research that students taking Algebra I in eighth grade are receiving watered down curriculum (2013). Based on this study, that does not seem to be the case in Virginia; however school divisions using either compressed or skipped curriculums may alter the pacing of an Algebra I course in middle school.

The second semester of Algebra I is inherently more difficult than the first semester as students move into working with polynomials, factoring, and laws of exponents. Some school divisions have chosen to expand the time allowed for teaching Algebra I content by offering a split Algebra I curriculum. Part 1 is completed in eighth grade in middle school, and part 2 is completed in ninth grade at the high school as noted by three suburban school divisions and one rural division in this study.

Capacity

Even though this study presents a representative sample of rural, urban, and suburban school divisions, there are challenges facing smaller districts which affect their choice of curricular pathway due to limited resources. Rural divisions usually have smaller budgets than their larger suburban and urban counterparts due to smaller population and sometimes lower property values (see Chapter 4, Table 6 and Table 7).

Smaller school divisions may have a lack of staff available to teach the courses needed, particularly since a minimum of Algebra I certification is required for accountability purposes. Loss of an Algebra-certified staff member may require adjustment of available math courses until a replacement is found. One rural division in this study commented on the need to shift from using a compressed curriculum to a skipped curriculum due to budget cuts which cut staff in their K-7 school. A rural school division utilizing skipped curriculum may not have the budget to offer the summer academies used by suburban and urban schools which help bridge Math 8 content for students moving directly from Math 7 to Algebra I.

Physical logistics can be difficult to manage as well, with the need to move students between school buildings for space or instructor reasons. Virtual Virginia – an online course system provided by VDOE - does not offer Algebra I as a course, and some smaller districts may need to turn to a computer-based math program to meet their students' needs. As the number of students taking Algebra I in middle school continues to grow these school divisions will struggle with how to provide learning opportunities for their students.

The Relationship between Curricular Pathways and SOL Pass Rates

Statistical analysis in this study showed that there is a relationship between curricular pathways and SOL pass rates. Regardless of using a skipped or compressed pathway, most school divisions achieved an average pass rate of 70% or higher for eighth graders taking the Algebra I EOC test in2012. The same holds true when scores are analyzed for an optimal range of 90-100%, with both skipped and compressed returning the same 40% to 60% distribution. For 2013, compressed curriculum gained an edge at 53.6% to 46.4% which remained consistent for the optimal score range.

While many studies have looked at the effect of tracking on students' self-perception of mathematics ability, this study compared the track taken with educational outcomes in the form of state assessment testing. While no clear delineation exists between using a skipped or compressed curriculum at this point, continuing to study the outcome data in years ahead may show compressed curriculum will continue to gain a lead.

The relationship between curricular pathway and SOL scores is important for reasons beyond just showing student success or failure rates. All states use standardized assessments for accountability purposes, but more and more states are tying student outcomes on these assessments to teacher reviews and pay. Students are increasingly finding themselves identified by data points such as test scores which are used to determine their future educational paths both in high school and college. So while the choice of a curricular pathway is not statistically significant, it is highly significant in its ability to affect the lives of teachers and students.

In addition to teachers and students, school divisions can be affected by these data.

Two rural divisions commented on the political sensitivity to Algebra scores in this age of accountability. Both cited push-back from high school principals towards implementing an eighth grade Algebra policy, fearing that the loss of more competent math students from the pool of Algebra I students in high school would "leave our weaker students' Algebra I, Geometry, and Algebra II scores to calculate accountability." Another rural division commented that "the Secondary and Middle levels consistently fight over these students and utilizing their success rates on SOL assessments for their overall math scores." For a smaller rural division even a few students could make the difference in meeting goals for accreditation.

Implications for Practice – Going Beyond Middle School

While taking Algebra I in eighth grade seems to be a middle school issue, many of the concerns expressed by study participants highlight their worries that they are making the right choices in the long run for their students. Having previously discussed entry onto, placement in, and what occurs on these curricular pathways during middle school, this section will consider how decisions made in middle school affect students beyond that realm.

Too Much Too Soon?

National debate continues to swirl about placing students into the high level class that of Algebra I while they are still in middle school (Loveless, 2013). Students should be well-prepared for Algebra I (NCTM, 2008), and it is clear that preparing more students to attempt the course at that time would benefit all (NMAP, 2008b). Study participants agreed, commenting that "there are many benefits to Algebra I in eighth grade and exposing students to rigorous content...prior to high school can better prepare students for college and career." Yet the comments received ranged from being "extremely pleased" with the method used to put students in Algebra I to worry at the level of success "depending on student maturity."

In reading the comments, the researcher felt that participants are deeply worried that they are doing the right thing for their students. As one survey respondent put it, "The pressure of SOL's, graduation requirements, and conflicting reports about what college ready requirements are, have pushed high school expectations into the middle school. Students are being pushed into Algebra I before they are developmentally ready and before they have a solid foundation of basic mathematics." Based on research in developmental theory and information processing, should we be pushing this mathematics at all students while they are still in middle school? Another respondent replied that "...this is a good question and one that we struggle with. The main philosophical question is: Are all kids ready for Algebra in eighth grade? We believe that (our) current curriculum may not adequately prepare all students for taking Algebra in eighth grade." Another urban division, worried about increasing numbers of students beginning Algebra early, commented that "...this path is not recommended by our guidelines except for very few students, but in some schools principals want a Geometry class in 8th grade and are starting a group of students on this track.

Providing more content in less time comes to us from the world of gifted education, where it is known as curriculum compacting, and it is utilized to allow students time for more in-depth study and independent research pursuit (Reis & Renzulli, 1992). There is not a broad research base to support its use with the general population. Perhaps the worry expressed by survey respondents stems from fear of making false assumptions that this will hold true for the general population as well. Students who are truly gifted mathematically need to learn with their peers, as research has shown that grouping them with average-ability students causes a decline in learning and performance (Nomi, 2012).

Would we better serve students in the long run by focusing more on depth and understanding of topics, giving students time to grow into abstract thinking and deductive reasoning rather than requiring those skills on top of learning new, unfamiliar material? This would lay a firmer base in cognitive and processing skills and would give students a better chance of success when they take Algebra I in high school. That does mean that students who are not in Algebra should sit through a re-hash of previously taught concepts. Virginia has increased the rigor of content in Math 8, creating a sort of bridge class from middle school mathematics to the Algebra I and Geometry that students must take for high school graduation. Both the Virginia standards and the Common Core include more Algebra content in Math 8 than was previously taught, giving students who need it the extra time to practice and master those concepts before moving on to the formal Algebra course. A combination of this more interesting and rigorous content with teaching that focuses on depth and problem-solving would not only better prepare students for high school mathematics but would also keep them more interested in mathematics.

Ready, Set, Go?

Passing the Algebra I test is only the start to a student's mathematics career in high school and hopefully beyond. The required pass rate score for the Algebra I EOC test is only 50%. Will students be able to be successful in Algebra II and beyond with a score that low? Perhaps a better indicator of how a more-inclusive middle school Algebra policy is faring would be to look at the grades for Algebra II and other higher level math classes. One rural respondent stated that "our students who struggle going into sixth grade at age appropriate instruction have become "at-risk" by the time they get to Algebra in HS because lack of basic mastery puts those students at a severe disadvantage in terms of meeting math and graduation requirements."

Another rural division coordinator commented that, "this system also hurts our mid-upper level students. They are meeting basic requirements and passing SOL's, but are not mastering the material. Therefore, when they get to higher level math classes that require more high level thinking and rely less on repetition of algorithms, these "good" students struggle. They now struggle in 10th and 11th grade making it less likely that they will take four years of math in high school. When they do take a fourth math class it is usually is an elective and often a class with much lower requirements than Trigonometry and calculus." The lack of mastery in skills early on leads to difficulty later in the higher math classes we want students to take in high school.

Putting the Cart before the Horse

The original intention of starting Algebra earlier was to have more students successfully complete more math in high school and improve the chance that they will go on to pursue a STEM career. According to the literature, the goal of an algebra-for-all policy that promotes completion of Algebra I in the middle school is to better prepare students for college and career readiness (Achieve, 2008). The question now comes down to quantity versus quality – are we rushing to have large numbers of students complete Algebra I in eighth grade but they are still not well prepared to go on to college?

One division commented that "from the student standpoint we have a bit of concern that a math class may not be taken their senior year if they start the advanced math early. As you know, a year without math then enter into the college world – very well may put the student at risk of failure at the college level." Another survey respondent from a rural division commented that, "in my opinion, the reason we have such a shortage of students interested in STEM is directly related to math sequencing and a focus on proficiency based on algorithms and repetition over mastery of material. Stated simply, for most of our students math has limited real world meaning and is not fun." In neither case has the goal of going further with math been accomplished.

By starting Algebra in middle school, students will complete the mathematics requirement for graduation by their junior year if not earlier. They may also be burnt out on math as a subject by this point too. What options do they have at this point? Math educators see calculus as the beginning of college math preparation – the first course in a college mathematic sequence. Students, on the other hand, see calculus as the culmination of five years of studying mathematics (Usiskin, 2003). After being told for years "you'll need this for calculus" they have finally arrived.

But what if a student is not interested in completing calculus in high school or in college? Virginia is exploring offering a culminating high school math capstone class, focusing on students who know they will go on to further training beyond high school but not necessarily pursue by immediately pursuing a four-year college degree. Offering dual enrollment options for computer simulation, computer modeling, or statistics would also be possibilities. The continued growth of online learning would provide opportunities to students even if they live in a rural area. Offering options beyond calculus may help alleviate the worry that students will not continue in mathematics.

Considerations for Further Research

In the planning stages of this study, the researcher intended to delve deeper into what happens to students once they are in Algebra I in eighth grade. However, a decision was made to begin by first conducting this trend research in order to gather evidence about current practices and possible effects.

More research is needed in determining how to assess Algebra readiness. Right now, no reliable and valid instrument is in widespread use. The more underprepared students we put into Algebra I in middle school, the more likely they are to struggle in high school (Loveless, 2013). Developing an instrument with direct correlation to Algebra I topics is critical, as is helping school divisions to implement it.

Of interest now would be study into how schools provide their Algebra I curriculum in middle school. Are leveled classes used? Is the course split into Part 1 and Part 2? How much instructional time is allocated daily/weekly? What options are available to a student who is not succeeding in Algebra I? How many expedited retakes of the Algebra I EOC occur, and how many students decide to expunge their grade and repeat the course in ninth grade? If they retake the course, are they successful? Data in these areas might help make better sense of the optimal delivery method for Algebra instruction in middle school.

More research should continue as well into options for students who do not take Algebra I in middle school. What can be done to provide a curriculum that is challenging and interesting yet fills in knowledge gaps and helps to increase the mathematics confidence of students who are seen as not performing well in mathematics?

One promise of common state standards is that over time they will allow research on learning progressions to inform and improve the design of standards to a much greater extent than is possible today. The CCSS-M provides a more integrated approach to high school mathematics rather than the single-subject courses currently in use. If Virginia chooses to adopt CCSS-M, research will be needed to see if an integrated or separate curriculum provides the better advantage.

Conclusion

This research study has provided a look into how Virginia school divisions are structuring a way for students to complete Algebra I while still in middle school. Most students do not officially enter their curricular pathway until they reach middle school in sixth or seventh grade, yet the roots of success are sewn in the elementary grades. Previous performance on state assessments and grades in earlier math classes are the predominant criteria used by schools to allow or decline access these curricular pathways. Even if there is a policy in place, the student may or may not enter a curricular pathway depending on the weight given to teacher and parental input. There is no statewide agreement on the best curricular pathway to attain the goal of Algebra I success in middle school. The pathway that a student is on will likely vary if he/she moves to another school division and may even change while he/she is still enrolled at the same school.

My hope as a math educator is that we will work towards treating Algebra I as a welcoming door to future mathematics rather than as a restrictive tollbooth through which students pass. The numbers prove that the United States has increased the number of students participating in Algebra I in the eighth grade. Now we need to be sure that they are also succeeding in that course and in further high school mathematics courses.

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Appendix A: Survey Questions

This appendix includes a Word-document created version of the survey which shows how the survey used branching logic to allow respondents with different policies to complete the survey.

The original survey was administered online using Qualtrics software. Respondents received a link to the survey in the original email they received.

Algebra Survey

Welcome and thank you for participating in this survey. The purpose of this survey is to determine the curricular pathways that students in Virginia school divisions utilize to reach Algebra I in the eighth grade. Once known, the pathways will be analyzed with SOL scores to determine if there is correlation. The results of this study will be shared with Virginia school divisions to help better inform policy decisions. Your participation in this study should take a total of about 10-15 minutes.

All information obtained will be kept confidential and your name will not be associated with any results of this study. There is no personal risk or discomfort directly involved with this research, and you are free to withdraw your consent and discontinue participation in this study at any time.

The primary researcher for this study is Melinda Griffin, a doctoral candidate at the College of William & Mary. You may contact her at mrvaug@email.wm.edu or 757-570-2741.

If you have any questions or problems that arise in connection with your participation in this study you may contact Dr. Tom Ward at the College of William & Mary at tom.ward@wm.edu or 757-221-2358.

THIS PROJECT WAS APPROVED BY THE COLLEGE OF WILLIAM AND MARY PROTECTION OF HUMAN SUBJECTS COMMITTEE (Phone 757-221-3966) ON 2014-01-17 AND EXPIRES ON 2015-01-17.

Please enter your name and the date in the space below to indicate that you consent to participating in this survey.

Name:	Date:

1) Please enter your name, school division, and position in the spaces below:

Name:

School division:

Position:

2) Place an X next to the category that best describes your school division:

	Urban		Suburban		Rural

3) Place an X next to the statement that describes your experience. Choose all that apply:

	I majored or minored in mathematics.		I have taught mathematics at the secondary level.
	I have an endorsement to teach mathematics (general or secondary).		None of the above

4) Does your school division have a policy and/or standard practice for putting students on a curricular pathway to take Algebra I in eighth grade? In other words, is there one set sequence of math courses prescribed by the school division that most students take in order to reach Algebra I in eighth grade?

Please note that this question does not refer to or include students who take Algebra I earlier than 8th grade.

	YES	Please proceed to Question 5
	NO	Thank you for participating in this survey. Please indicate to me when you return the survey if I may contact you with any further questions.

5) An entry point is defined as the grade level at which a student enters a track to complete a set sequence of mathematics courses.

What are the entry point(s) in your school division for a student to be on track to take Algebra I in eighth grade? Choose all that apply.

Please note that this question does not refer to or include students who take Algebra I earlier than 8th grade.

	4th Grade or Earlier		7th Grade
	5th Grade		8th Grade
	6th Grade		

6) A student taking Algebra I in middle school is considered 1-2 years head in mathematics according to Virginia's Standards of Learning, which consider Algebra I as the first high school level mathematics course.

For the 2013-2014 school year, which of the following best describes how your school division enables students to take Algebra I as an eighth grader? Place an X by your choice.

	Curriculum compressing – students learn all Virginia SOL content through Grade 8 mathematics prior to starting Algebra I. For example, students may have access to Math 6 and Math 7 in a blended class.
	Skipping content – students do not access one year of prescribed Virginia SOL mathematics content. For example, students would take Math 6 then skip Math 7 to go on to Math 8.

7) Is this policy/practice different from what was used in either the 2011-2012 or the 2012-2013 school year?

	YES: As the curricular pathways used by your division have changed, you will find questions concerning each separate school year, starting with 2011-2012, through 2012-2013, and concluding with 2013-2014. If you chose Curriculum Compressing in Question 6, GO TO QUESTION 16 If you chose Skipping Content in Question 6, GO TO QUESTION 17
	NO: Please skip to Question 14

8) A student taking Algebra I in middle school is considered 1-2 years head in mathematics according to Virginia's Standards of Learning, which consider Algebra I as the first high school level mathematics course.

For the 2011-2012 school year, which of the following best describes how your school division enables students to take Algebra I as an eighth grader? Place an X by your choice.

	Curriculum compressing – students learn all Virginia SOL content through Grade 8 mathematics prior to starting Algebra I. For example, students may have access to Math 6 and Math 7 in a blended class.
	Skipping content – students do not access one year of prescribed Virginia SOL mathematics content. For example, students would take Math 6 then skip Math 7 to go on to Math 8.

9) If you used curriculum compressing during the 2011-2012 school year to enable students to take Algebra I in eighth grade, which combination best describes the sequence of courses used in your division?

	Math 5	Blended class of Math 5&6	Math 6	Blended class of Math 6&7	Math 7	Blended class of Math 7 & 8	Math 8
As a 5th grader the student took…							
As a 6th grader the student took…							
As a 7th grader the student took…							

10) During the 2011-2012 school year, which classes would a student taking Algebra I in eighth grade have skipped?

	Math 5
	Math 6
	Math 7
	Math 8

11) Assuming that an eighth grade student from your school division is taking Algebra I (and therefore the Algebra I End-of-Course test), please list the SOL tests taken previously by this student according to your school division's course sequencing policy for the 2011-2012 school year.

	Math 5 SOL test	Math 6 SOL test	Math 7 SOL test	Math 8 SOL test
At the end of 5th grade this student took the ….				
At the end of 6th grade this student took the…				
At the end of 7th grade this student took the …				

12) A student taking Algebra I in middle school is considered 1-2 years head in mathematics according to Virginia's Standards of Learning, which consider Algebra I as the first high school level mathematics course.

For the 2012-2013 school year, which of the following best describes how your school division enables students to take Algebra I as an eighth grader? Place an X by your choice.

	Curriculum compressing – students learn all Virginia SOL content through Grade 8 mathematics prior to starting Algebra I. For example, students may have access to Math 6 and Math 7 in a blended class.
	Skipping content – students do not access one year of prescribed Virginia SOL mathematics content. For example, students would take Math 6 then skip Math 7 to go on to Math 8.

13) If you used curriculum compressing during the 2012-2013 school year to enable students to take Algebra I in eighth grade, which combination best describes the sequence of courses used in your division?

	Math 5	Blended class of Math 5&6	Math 6	Blended class of Math 6&7	Math 7	Blended class of Math 7 & 8	Math 8
As a 5th grader the student took…							
As a 6th grader the student took…							
As a 7th grader the student took…							

14) During the 2012-2013 school year, which classes would a student taking Algebra I in eighth grade have skipped?

	Math 5
	Math 6
	Math 7
	Math 8

15) Assuming that an eighth grade student from your school division is taking Algebra I (and therefore the Algebra I End-of-Course test), please list the SOL tests taken previously by this student according to your school division's course sequencing policy for the 2012-2013 school year.

	Math 5 SOL test	Math 6 SOL test	Math 7 SOL test	Math 8 SOL test
At the end of 5th grade this student took the ….				
At the end of 6th grade this student took the…				
At the end of 7th grade this student took the …				

16) If you used curriculum compressing during the 2013-2014 school year to enable students to take Algebra I in eighth grade, which combination best describes the sequence of courses used in your division?

	Math 5	Blended class of Math 5&6	Math 6	Blended class of Math 6&7	Math 7	Blended class of Math 7 & 8	Math 8
As a 5th grader the student took…							
As a 6th grader the student took…							
As a 7th grader the student took…							

17) During the 2013-2014 school year, which classes would a student taking Algebra I in eighth grade have skipped?

	Math 5
	Math 6
	Math 7
	Math 8

18) Assuming that an eighth grade student from your school division is taking Algebra I (and therefore the Algebra I End-of-Course test), please list the SOL tests taken previously by this student according to your school division's course sequencing policy for the 2013-2014 school year.

	Math 5 SOL test	Math 6 SOL test	Math 7 SOL test	Math 8 SOL test
At the end of 5th grade this student took the				
At the end of 6th grade this student took the...				
At the end of 7th grade this student took the ...				

19) What placement criteria are currently used by your school division to determine if a student can take Algebra I in eighth grade? Please check all that apply.

	SOL test score(s)		Teacher recommendation(s)
	Benchmark test score(s)		Parent/Guardian input
	Placement test score(s)		We do not use placement criteria at all. There is open enrollment for Algebra I in eighth grade.
	Classroom grade(s)		

20) The purpose of this study is to understand how school divisions are implementing Algebra-for-All initiatives and to identify the potential benefits and drawbacks from these decisions. Please use this space to explain or describe any additional insights you have that might help answer this research question.

21) May I contact you if I have any further questions?

	YES		NO

Thank you for your participation in this survey.

Please save your responses as a Word document with this format:

Last name_First initial.docx

Email the completed survey to mrvaug@email.wm.edu with the subject line "Completed Survey."

Thank you again, and have a wonderful day.

Appendix B: Survey Letters

Initial Request – Sent via email on January 24, 2014

Good morning, ___________,

I am conducting a study to determine the curricular pathways that students in Virginia school divisions utilize to reach Algebra I in the eighth grade. As more and more Virginia students are completing Algebra I in middle school rather than in high school, we are studying how school divisions are enabling students to accomplish this goal. The results of this survey will be shared with participating school divisions to help better inform policy decisions.

I am including a link to an online survey which is being used to collect data for the study. Please use the password "math" to enter the survey.

https://wmsurveys.qualtrics.com/SE/?SID=SV_0JMyn3QZs01YPI1

The survey includes questions on what courses students take leading up to Algebra I in eighth grade, and if this sequence of courses has changed during the past three years. You will also be asked about the placement criteria used to determine if a student takes Algebra I in eighth grade and what SOL tests students take at each grade level as they progress through middle school.

Your participation in this study should take a total of about 10-15 minutes. All information obtained will be kept confidential and neither your name or your school division will be associated with any results of this study. There is no personal risk or discomfort directly involved with this research, and you are free to withdraw your consent and discontinue participation in this study at any time.

Please feel free to contact Dr. Gareis or myself with any questions, and I thank you for your time.

Sincerely,

Melinda Griffin
Doctoral Candidate
The College of William and Mary
mrvaug@email.wm.edu

Dr. Christopher Gareis
Associate Dean for Teacher Education & Professional Services
The College of William and Mary

crgare@wm.edu

THIS PROJECT WAS APPROVED BY THE COLLEGE OF WILLIAM AND MARY PROTECTION OF HUMAN SUBJECTS COMMITTEE (Phone 757-221-3966) ON 2014-01-17 AND EXPIRES ON 2015-01-17.

Second Request – Send via email on February 17, 2014

Dear ______________,

A request to complete our Algebra I survey was sent to you on January 24th. As I have not yet heard from your school division, I am resending the original request to you. This survey will close on Wednesday, February 26, 2014.

I hope that your school division will choose to be a part of this research which will give participating school divisions insight into how our middle school students are completing Algebra I prior to entering high school. Please feel free to forward this request to another member of your school division if needed.

Thank you for your consideration, and if you have any questions, please do not hesitate to contact me.

Sincerely,

Melinda Griffin
The College of William & Mary
mrvaug@email.wm.edu

Original message follows:

Good morning, ______________,

I am conducting a study to determine the curricular pathways that students in Virginia school divisions utilize to reach Algebra I in the eighth grade. As more and more Virginia students are completing Algebra I in middle school rather than in high school, we are studying how school divisions are enabling students to accomplish this goal. The results of this survey will be shared with participating school divisions to help better inform policy decisions.

I am including a link to an online survey which is being used to collect data for the study. Please use the password "math" to enter the survey.

https://wmsurveys.qualtrics.com/SE/?SID=SV_0JMyn3QZs01YPI1

The survey includes questions on what courses students take leading up to Algebra I in eighth grade, and if this sequence of courses has changed during the past three years. You will also be asked about the placement criteria used to determine if a student takes Algebra I in eighth grade and what SOL tests students take at each grade level as they progress through middle school.

Your participation in this study should take a total of about 10-15 minutes. All information obtained will be kept confidential and neither your name or your school division will be associated with any results of this study. There is no personal risk or discomfort directly involved with this research, and you are free to withdraw your consent and discontinue participation in this study at any time.

Please feel free to contact Dr. Gareis or myself with any questions, and I thank you for your time.

Sincerely,

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THIS PROJECT WAS APPROVED BY THE COLLEGE OF WILLIAM AND MARY PROTECTION OF HUMAN SUBJECTS COMMITTEE (Phone 757-221-3966) ON 2014-01-17 AND EXPIRES ON 2015-01-17.

Appendix C: Coded Comments

Topic	Quote from comments
Entry Points	S, S4: Another consideration is how to provide multiple ways for a student to "jump tracks" and get to Algebra. And, how to ensure that if they do that they have all the necessary instruction to make them successful.
Parents	R, C9: "Some parents push their children too quickly without understanding the long term developmental needs of their child" S, S4: When a student enters 8th grade there is an open enrollment policy for all classes. 7th grade math teachers have discussions with each child (and often parents) about what they believe is the best choice for them as an 8th grader. They (and their family) do not always agree and select a more rigorous class than recommended. This has been a problem for both students, teachers, & counselors. If or when the class becomes too difficult for the students, both teacher and parents become frustrated at why the student is not successful. R, S2: In many cases math has become a competition for community status. R, S2, C9, C9: Much time has been spent creating the division curriculum pathway for students. At times, administrators make exceptions for a student(s) without consulting data or the division math specialist. Hasty decisions have usually backfired. R, S9, C4, C4: Parents have a huge part of whether this will be successful or not. Many of our parents want their children taking Algebra in 7th grade R, S3: We also gave parents and students the right to opt out of this pathway if after the first 6 weeks grading period the students felt frustrated or overwhelmed. These students entered our 8th grade curriculum (pre-algebra) as 7th graders. Students and parents, with teacher input, are given the option of continuing to algebra I in 8th grade.

Teachers	R, C9: "Some teachers have a belief problem and occasionally complain about working with students who are the weaker of the strong students" S, C9: We are having less students take Algebra I in the eighth grade due to better screening by our seventh grade math teachers. R, S3: To be honest, we had a considerable amount of opposition to this plan initially. Some teachers at the high school level doubted that students could be successful in algebra I at grade 8, but our results have proven that our procedure works.

Policy	R, C9: "Trying very hard to ensure that students only take Algebra if they are ready in the 8^{th} grade" R, S2: The pressure of SOL's, graduation requirements, conflicting reports about what college ready requirements are, have pushed high school expectations into the middle school. Students are being pushed into Algebra I before they are developmentally ready and before they have a solid foundation of basic mathematics R, S3: I am extremely pleased with the method that we use to put students in algebra I at the 8th grade. Our students are extremely successful in algebra I and the only students who fail the end of course sol algebra I test are those who transferred into our school system from another. R, S3: I've heard talk of students taking algebra I earlier than 8th grade and this bothers me. I don't know that there are many students who could accomplish this feat. R, S3: A lot of success in algebra I depends on the maturity level of the student. At one point someone also mentioned taking algebra I for one semester and taking geometry in the second semester. i don't like that idea either, but maybe I'm just too set in my ways. R, C9: We are finding that not all students are ready for Alg. I in grade 8 and are adjusting our plans for the 2014-2015 school year. S, S4: This is a good question and one that we struggle with. The main philosophical question is: Are all kids ready for Algebra in 8th grade? Does our curriculum prepare students properly for this track.. We believe that in **** our current curriculum in 6th and 7th grade may not adequately prepare ALL students for taking Algebra in 8th grade.

	R, S4,S4,C9: We are transitioning from "skipping curriculum" to a "compressed curriculum" the past two years. S, S4: We are not implementing an "Algebra for all" initiative; approximately 60% of our middle school students complete Algebra I by the end of 8th Grade. R, S4: I think the lack of course compression of material can cause some students to struggle in higher levels of math. However, many students will be able to proceed without problem considering material covered in Math 7 often mirrors material in Math 8.
Implementing the curriculum: Before Algebra	S, C9: "Math 7 in 7^{th} grade (compressed content from math 7 and math 8" U, S4: Additionally our middle schools have 90 minutes of math every day. U, S4,S4,C5: We have changed our sequencing over the past year and a half, so the students currently in Algebra in the 8th grade did skip the Math 8 course and test. We compacted 5th and 6th grade last year, and the 6th graders did 6th and most of 7th. This year, our students have had compacted courses so that next year, all 8th graders in Algebra will have covered all content. S, C9: When Algebra for All in grade 8 began, our middle school math curriculum changed. Math is offered every day for an 80+ minute block. Essentially math is double blocked in middle school in order to deliver a compressed curriculum in grades 6 and 7. U, C9: We have three course offerings at grades 6, 7 and 8. Grade 6, only 6 grade standards: students take grade 6 SOL Assessment Grade 6 Honors, Grade 6 and 50% of Grade 7 standards: students take grade 6 SOL Assessment Pre-Algebra - Compress; grades 6, 7, but all of grade 8 standards: students take grade 8 SOL Assessment Grade 7, only grade 7 standards: students take grade 7 SOL Assessment Grade 7 Honors, complete remainder of grade 7 standards and all grade 8 standards, students take grade 8 SOL Assessment Grade 7 Algebra I for students who successfully completed Pre-Algebra. students take Algebra I SOL Assessment Grade 8, only grade 8 standards, students take grade 8 SOL Assessment Algebra I, Course II Honors students: students take Algebra I SOL Assessment Geometry for students who successfully completed Algebra I in grade 7: students take geometry SOL Assessment.

	R, S4: I do think there is more of a gap that might exist if students take Math 6 (even if advanced) and go right to Algebra I in 7th grade. R, C10: As of this school year, we have also implemented a small amount of blending between 4th and 5th grade mathematics. Certainly nothing as extensive as the fifth, sixth, and seventh grade blending process. It is our hope that this blending and bridging process will help teachers better identify the students who are the best candidates for the track leading to Algebra I in the eighth grade, R, S4: Things changed when the standards changed and there was a big move to take 7th grade math. So our division have all 6th grade students taking sixth grade math and the sixth grade SOL. The next year these students will take 7th grade math and the 7th grade SOL. Depending on 7th SOL Score and progress in this 7th grade class, those students that pass SOL and the class go straight to Algebra I as eighth graders. S, C9: We provide all of our students with a comprehensive approach to teaching and learning to prepare them for the demands of rigorous mathematics. We believe that though ongoing exposure to rigorous content and experience with the thinking processes (Process Standards - NCTM) needed to analyze, solve, and explain complex math problems, students will be equipped with the skills needed to be successful in advanced mathematics courses beyond AP/IB courses. It starts in elementary school. S, C9: It is my belief that students need to thoroughly master and experience the middle school curriculum in ways that build understanding of concepts - not memorization of procedures and short cuts. Since we have in most schools 60-88 minutes a day for math, we should be able to prepare more students for Algebra I by 8th grade.
Implementing the curriculum: Algebra course	R, C4: "most eighth graders take Algebra I-A in the eighth grade. " S, C9: "...Algebra I, Part 1 in the 8^{th} grade" S, S4: Of the 10 sections of math we offer at the 8th grade level, eight are considered advanced classes. The two sections of Math 8 are needed for students to build a stronger foundation so they are more successful in Algebra 1. S, C9: our eighth grade students taking Algebra I are only in this class for a semester (block schedule - also our eighth graders go to our high school, which is a 8-12 school), thus we need to ensure that the eighth graders taking Algebra I can handle the pace of the class.

	R, S4: Material in Math 8 curriculum is often covered again in Algebra I as well. S, C9: We currently have approximately 37%-40% of middle school students completing Algebra I before the end of middle school. Our middle school Algebra I course covers all of the Algebra I SOL and a small part of Algebra II SOL.
Bridging content: adding to Algebra	R, C4: "Math 8 content that has not been previously covered is included in the course as well as a review of all Math 8 concepts. Students take the Math 8 SOL test at the end of the course." U, S4: Missed content is infused into the Algebra curriculum. R, S4: We have found instructional gaps in the curriculum when implementing Algebra I in 7th grade. Through district wide teacher meetings we have been able to identify those gaps and address them at the beginning of the year (Alg I) and throughout as needed"
Bridging content: frontloading	RS4: Our plan is for students to skip 8th grade math but to infuse those skills needed for success in Algebra into their 7th grade classes. S, C9: For students who are not selected for Extended courses based on elementary school data can participate in the following when they are academically ready: 1. Students can take a Bridge to Extended Math 7 after Grade 6 to be placed in Extended Math 7 as a 7th grader. 2. Students can take a Bridge to Adv Algebra I after Grade 7 to be placed in Adv Algebra I as an 8th graders.
Bridging content: Summer academies	U, S4: We have the Algebra Readiness Academy in the summer that fills gaps. S, S2, S4,S4: We offer an optional summer school "course" called Bridges to Algebra. This is designed for students who will be moving directly from Math 7 to Algebra 1. It includes a majority of the content in grade 8 math that students would not otherwise see, with a heavy emphasis on solving equations an inequalities.
SOL Test Patterns	R, S4: "Math 8 content that has not been previously covered is included in the course as well as a review of all Math 8 concepts. Students take the Math 8 SOL test at the end of the course."
See no need	R, S4: "no drawbacks identified" U, S4: Nothing to add

for changes	

Placement	R, S4: We are working to put more students into Algebra by 8^{th} grade. Currently there are about 35% of our students who have taken Algebra by the end of their 8^{th} grade." S, C6: We are taking a closer look at 5^{th}, 6^{th}, and 7^{th} graders to see if their data shows they are ready for Algebra I by eighth grade. R, S4: SOLs and ARDT scores were helpful at one time but as these tests are changing, we are still adjusting to their new scores. U, S4: The majority of our students take Algebra I in grade 7. R, S4: Our determination criteria is the use of the ARDT, grades, previous SOL tests, teacher input as well as parent input. S, S4: Students who are taking advanced math courses prior to 8th grade must meet criteria for enrollment in those classes. Teachers use a significant amount of data to make those decisions and parent with concerns discuss those placements with the teacher and/or me. R, S2: We have created a socio-economic class based tracking system in math. U, C9: We also look at student success on the Reading SOL assessment in grades 6 and 7. R, C7: We use Cortez for Math 7/8. So the student's SOL score on the 8th grade SOL assessment and the progress and mastery of the Cortez Curriculum is used in deciding who is ready to move to Algebra I in 8th grade. R, C6: While we do use multiple data points for a placement recommendation, ultimately there is open enrollment in that families can decide placement after getting the rec. R, S4: Our division made a switch from having a placement test in 5th to see which students could skip 6th grade math and proceed to 7th grade math. The next year these students as 7th graders took the 8th grade math test so as 8th graders they were able to take Algebra I. R, S3: When we made this pathway change for our students, we began by identifying 6th grade students whose SOL, ARDT and other common assessment scores, as well as classroom performance suggested readiness for acceleration. (We now also use a math universal screening tool--Scholastic Math Inventory--to the list of assessments.) The principal and teachers talked with parents and the students to determine if they felt they

	were ready to tackle accelerated content. R, C10: We have had great success in offering Algebra 1 to students in Middle School who demonstrate good student skills, conceptual understanding, problem solving and fact fluency. Students who are weak in one or more of these areas have difficulty in mastering content presented in the second semester of Algebra S, C9: 3. During the first 6 weeks of school, we re-assess the placement of students to ensure all students are properly placed. This means that a students can move into an extended course during this time or be moved into a non-extended course. S, C9: Although we have Division guidelines for placement into our Extended Math 6, Extended Math 7 and Algebra courses in middle school, these guidelines are not followed by all schools. Some implement more stringent requirements, while at least one school has open-enrollment (and also had the highest number of failures on the Algebra I SOL last year). S, C9: Approximately 200 of our students last year were in Algebra I in 7th grade and had skipped over the 6th and half of the 7th grade curriculum. This path is not recommended by our guidelines except for very few students, but in some schools, principals want a Geometry class in 8th grade and are starting a group of students on this track. R, S4: We are finding that our placement criteria for Algebra I in 8th need to be altered as we are seeing some students who are placed into Algebra I in 8th grade, following completion of Math 7 are not successful. We currently have a division-wide committee reviewing our math course pathways and placement criteria.

Capacity	S, C6: We are also working with local community college to get more of our middle school teachers qualified to teach Algebra I. At present, we are limited on staff qualified at middle school level to teach Algebra." R, C9, S4, S4: We are consistently tweaking to make sure we have the best possible courses for our students. Budget cuts made a huge difference in the ability to compress grades. We do not have a middle school, so our elementary is K-7 then our high school is 8-12. Losing positions in the elementary grades hurt our ability to compress so we went to skipping content instead. R, C9, S4, S4: Parents have a huge part of whether this will be successful or not. Many of our parents want their children taking Algebra in 7th grade and being bused to the high school which has also been difficult.

Politics	R, S4: Accreditation and AMOs at the high school level is our biggest concern at the moment. Those students who do not take Algebra I in middle school are typically our weaker math students, not always but typically. So this leaves our weaker students Alg I scores, Geometry scores, and Alg II scores to calculate accountability." R, S3: We had the greatest push-back from high school principals who felt that removing the 'best' students from their math testing pool would negatively impact their test scores. That has not been the case. S, C9: S, C9: Approximately 200 of our students last year were in Algebra I in 7th grade and had skipped over the 6th and half of the 7th grade curriculum. This path is not recommended by our guidelines except for very few students, but in some schools, principals want a Geometry class in 8th grade and are starting a group of students on this track.

Future math progress	R, S4: From the student standpoint we have a bit of concern that a math class may not be taken their senior year if they start the advanced math early. As you know, a year without math then enter into the college world - very well may put the student at risk of failure at the college level R, S2: Our students who struggle going into sixth grade at age appropriate instruction have become "at-risk" by the time they get to Algebra in HS, because lack of basic mastery puts those students at a severe disadvantage in terms of meeting math and graduation requirements. R, S2: This system also hurts our mid-upper level students. They are meeting basic requirements and passing SOL's, but are not mastering the material. Therefore, when they get to higher level math classes that require more high level thinking and rely less on repetition of algorithms, these "good" students struggle. They now struggle in 10th and 11th grade making it less likely that they will take four years of math in high school. When they do take a fourth math class it is usually is an elective and often a class with much lower requirements than Trigonometry and calculus. R, S2: In my opinion, the reason we have such a shortage of students interested in STEM is directly related to math sequencing and a focus on proficiency based on algorithms and repetition over mastery of material. Stated simply, for most of our students math has limited real world meaning and is not fun. S, C9: The students that wait and take Algebra I in the ninth grade, unless the eighth grade math teacher says otherwise, take Algebra I for the entire year. R, C6-9-9: We have found accelerating 7th graders to take Algebra 1 as a 7th grader is not working. We want students to take math thru 12th grade and most were not. S, S4: There are many benefits to Algebra in 8th grade... exposing students to rigorous content and providing that prior to high school can better prepare students for college and career. R, C9: the Secondary and Middle levels consistently fight over these students and utilizing their success rates on SOL assessments for their overall math scores U, C6: We are investigating Algebra-for-All because we realize that Algebra I is must for all students in grade 8. This will open up students' high school schedules and afford them greater opportunities to increase their course load. This will help us put greater emphasis on the current

	associate degree program that our school system is promoting to our students.

VITAE

Melinda Rose Griffin

Birthdate:	October 10, 1964	
Birthplace:	Melrose, Massachusetts	
Education:	2009-2014	The College of William and Mary Williamsburg, Virginia Doctor of Philosophy Educational Policy, Planning, and Leadership Curriculum Leadership
	2005-2009	The College of William and Mary Williamsburg, Virginia Master of Arts in Education Curriculum and Instruction
	2001-2003	Elizabeth City State University Elizabeth City, North Carolina Teacher Certification Elementary Education
	1982-1985	The University of Oklahoma Norman, Oklahoma Bachelor of Arts French