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An Analysis of the Mathematics Program at Jackson Christian School

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AN ANALYSIS OF THE MATHEMATICS PROGRAM AT JACKSON CHRISTIAN SCHOOL

A project submitted in partial fulfillment
of the requirements for the degree of
Masters of Education

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I HEREBY RECOMMEND THAT THE PROJECT PREPARED UNDER MY SUPERVISION BY Ruth Ellen Howdyshell ENTITLED An Analysis of the Mathematics Program at Jackson Christian School BE ACCEPTED IN PARTIAL RULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Masters of Education.

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ABSTRACT

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This analysis of a small private school's K – 12 mathematics program for about 325 students looks at the credentials and teaching methods of the faculty, the curriculum and its alignment to state standards, and the assessment scores of students. It gives suggestions for continuing to improve the stable program.

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Introduction to the Investigation

Jackson Christian School, in Jackson, Michigan, opened its doors to students in the fall of 1972. The first year of its existence the school had 69 students enrolled in its kindergarten to sixth grade program. The following year, grades 7 and 8 were added, and each year after that an additional grade was added, with the first graduating class receiving diplomas in 1978. Presently the school has an enrollment of over 300 students and instructs students from preschool to 12th grade. Its mission statement is "Equipping Students to Impact the World for Christ" (www.jacksonchristianschool.org). Throughout the years the school has had a strong academic program evidenced by scores on standardized tests and the number of students that continue their learning with college education and pursue careers that require an educational background. However, in the last few years some concerns have been expressed about the strength of the math program of the school. Therefore, the purpose of this investigation is to identify characteristics of a strong math program and to determine Jackson Christian School's strengths in its math program as well as identify areas where improvements could be made.

An important part of a quality math program is the curriculum that is taught. In 1989 the National Council for Teachers of Mathematics (NCTM) published *Curriculum and Evaluation Standards for School Mathematics* (www.nctm.org), which described important concepts to be taught in each grade from kindergarten through 12th grade. The standards were very helpful in that they created some uniformity in math instruction, but they were very numerous and "encouraged the development of a curriculum that has been

characterized as 'a mile wide and an inch deep'" (Protheroe, 2007). Recognizing the magnitude of the standards, NCTM developed *Curriculum Focal Points* in 2006 (www.nctm.org), which identified three curriculum focal points and connections for pre-kindergarten through eighth grade which would give students a comprehensive math curriculum and enable them to learn mathematical concepts in a "focused and cohesive curriculum that implements problem solving, reasoning, and critical thinking" (www.nctm.org). The State of Michigan then published two documents, namely *Grade Level Content Expectations for K-8* (www.michigan.gov) and *High School Course/Content Expectations and Guideline* for grades 9 – 12 (www.michigan.gov) to be used as more specific guides for educators in Michigan. Recently those standards were combined and organized into one document entitled *Common Core State Standards* (www.corestandards.org) which was released in June 2010. The aim of the Common Core State Standards document was to clarify and specify the conceptual understanding and skills the students should achieve in their study of mathematics and help organize principles such as place value and the properties of operations to structure those ideas.

Another integral part of a quality math program is skilled teachers. In fact, Susan Goya (2006) states that having teachers who are skilled in teaching math is the first prerequisite for improving math instruction. Teachers need to be able to focus on the "big ideas" of math and on the connections and sequences among the ideas so that the curriculum is coherent ("Early Childhood," 2003). They need to be able to help students grasp the concepts and be able to apply them in a variety of settings (Marshall, 2006).

Regarding the teaching of math, educators have debated whether learning should be skill-based and emphasize memorization of math facts and using standard algorithms

such as ones for addition, subtraction, multiplication, and division or whether learning should be discovery-oriented and emphasize finding more than one way to solve a problem and having students explain how they arrive at solutions (Protheroe, 2007). Some educators say teachers should emphasize procedural skills and provide much practice for the students in mastering skills when they introduce them to various mathematical concepts. Other educators say teachers should focus on problem solving by providing real world experiences where students can explore and discover mathematical concepts.

Each group of educators claims that research shows that their approach works better. Brian A. Bottage (1999) investigated the effect of contextualized math instruction, which encourages students to explore problems in a hands-on environment. His study of the performance of 66 middle school students in a rural Midwest school showed that when working on a contextualized problem or when transferring concepts to a related problem, students in a contextualized problem group significantly outperformed students who worked solely with textbook problems.

Jim Ysseldyke and Daniel M. Bolt (2007) investigated the effect of continuous practice of math skills on the students' math achievement. They found that on standardized achievement tests students whose teachers used continuous progress monitoring, such as an instructional management system that records student progress and generates new questions based on student work, significantly outperformed students whose teachers used only the curriculum regularly used in the classroom. The instructional management system they used recorded student progress and generated new questions based on student work.

Research does show that each method of instruction has its own strengths. In reality, learning is a complex matter affected by many factors. Though each method of teaching has its own merit, neither can be judged as more effective when all aspects are considered. Effective instruction is not just a dichotomy of one method versus another method. The National Academy of Science's Mathematical Sciences Education Board did a study on 19 mathematics curricula with their varied emphases, and they concluded that none of the programs met the scientific standards of significance necessary to gauge whether one program was more effective than another (Garelick, 2005). Therefore, perhaps the best approach for teaching is to strive for a balance between teaching for conceptual understanding and teaching for procedural fluency (Protheroe, 2007). After all, "instruction can emphasize conceptual understanding without sacrificing skill proficiency" (Hiebert, 2000).

Educators advocating discovery learning promote student-centered classrooms rather than teacher-directed (lecture-based) classrooms. They make use of manipulatives or hands-on materials to help students understand concepts, and they incorporate inquiry, discovery, and problem solving approaches for learning concepts. In addition they use calculators and technology for capturing and analyzing data from math and science experiments that students do, and they encourage students to communicate math concepts through journal writing, small-group discussions, and the laboratory/technical reporting of experiments. Furthermore, they seek to apply math concepts to real-world contexts and connect math skills to specific careers and occupations (Thompson, 2007).

The Third International Mathematics and Science Study (TIMSS) revealed that high-achieving Asian countries emphasize problem solving and the development of

conceptual understanding of the nature of the problems rather than just correct answers to the problems (Newton, 2007). If students do not understand the concepts behind the procedures they are doing, they are less likely to apply them and are more likely to forget them because things that are not understood are more likely to be forgotten (Marshall, 2006). In addition, fragmented knowledge that is not connected to other concepts is easily forgotten and results in a low retention rate for students (Marshall, 2006). There needs to be a connection and coherence throughout the course of instruction (Newton, 2007). Furthermore, assessment helps determine a student's conceptual understanding; however, assessment, such as standardized tests, may not reveal a true picture of whether a student understands a concept or is just good at guessing the correct answer (Newton, 2007). Conceptual understanding is best seen through constructed response answers.

In developing meaning and understanding, problem solving is important. A good way for students to develop meaning and understanding in math is to be involved in discussions of math problems as a whole group and in small groups (Nelson & Sassi, 2007). This provides a window into alternative solution methods and lets students hear solutions expressed in language used by their peers (Shellard, 2004). As teachers hear the different strategies that are used by students, they can promote the competent ones and expose flaws in ones that are not mathematically sound. Students also develop understanding by using a variety of manipulatives to explore and represent mathematical concepts (Nelson & Sassi, 2007). However, "Students do not discover or understand mathematical concepts simply by manipulating concrete materials. . . . [The teacher] must help students focus on underlying mathematical ideas" (Sutton & Krueger, 2002).

Teachers need to ask open-ended questions and listen carefully as students express their mathematical thinking (Nelson & Sassi, 2007).

In order to help students better understand concepts, teachers should make some adaptations or accommodations for differing learning styles. Teachers may need to use visual clues or help students when they read word problems (Shellard, 2004). They may need to assist students in creating and solving equations. They may need to help students understand through the exploration of tactile models or the creation of auditory patterns to associate information. In addition teachers may need to encourage students to verbalize strategies or create journal entries that describe concepts or information. Students learn in different ways and teachers need to use a variety of techniques to maximize each student's learning. Furthermore, Shellard (2004) states that teachers need to be careful in assigning homework to students when they do not understand a concept because students need to understand a skill or concept before being asked to practice it. Shellard (2004) also says that teachers should introduce only one concept at a time and teach it to mastery, teaching in small chunks so that students get lots of practice, one step at a time.

Not everyone agrees with Shellard's statement that concepts should be mastered one at a time. Bottage (1999) sees withholding the introduction of more complex and interesting content until easier material is mastered and the emphasizing of skill deficiencies rather than skill strengths as a detriment and disservice to students. For students who experience difficulty in learning math, these techniques, according to Bottage (1999), contribute to a "sense of hopelessness and concomitant behavior problems." He encourages teachers to engage students in real problem solving in order to

make learning more meaningful and to help promote student thinking. Though real problems often do not follow a linear, prescribed path to a solution, they do encourage students to make connections between concepts and help students learn when to apply procedures.

One of the difficulties that students have with math is that reading math text requires a different kind of reading skill than narrative or informational reading. Along with the regular reading skills, students also need to know how to read from right to left when reading a number line and from top to bottom and bottom to top when reading mathematical tables. They also need to read diagonally when reading graphs, and they have to read and interpret many symbols. Furthermore math text is succinctly written replete with significant details, which students must identify, in contrast to narrative text which weaves the important concepts throughout much verbiage. In addition, math vocabulary and content differ significantly from narrative and expository text vocabulary. Culyer (1988) stated in his research that mathematical texts contain more concepts per word, per sentence and per paragraph than any other type of textual material. A resource that has proved helpful in teaching students to read mathematical material is Barton & Heidema's (2000) book *Teaching Reading in Mathematics*. Some methods suggested to help students read mathematical texts are for teachers to think aloud to help students understand how to think through problems, to use graphic organizers, to use roots of words to determine unknown words, and to help students understand varied formats and directional words (Phillips, Bardsley, Bach, & Gibb-Brown, 2004).

Many schools have desired to improve their math programs and have implemented specific plans to reach that goal. Educators in Marion, Indiana, made major

improvements in their math program by implementing a curriculum that emphasized problem solving. The new program focused on the following four areas: meaning and understanding, problem solving, mastering basic facts and computational methods (within strict time limits), and studying all of the prescribed units at each grade. In a two year time span the students' average scores on the Iowa Test of Basic Skills rose 40 points (Wheatley, 1984).

The Marion, Indiana, program seems to be a balanced program that includes not only conceptual understanding of math but mastery of facts as well as procedural skills. One goal of their program focused on covering all of the prescribed concepts each year. Curriculum maps help a teacher budget classroom time so that all the essential standards or concepts are covered each year.

Assessment, both summative and formative, is a key factor in determining if students are grasping the concepts. In a study of 24 students in an urban elementary school, Christle and Schuster (2003) found response cards to be a valuable tool in doing formative assessment, allowing teachers to quickly see all the students' responses and assess their performance, modifying instruction as needed and giving students immediate feedback. Not only did the response cards assist in formative assessment, but Christle and Schuster found that the response cards increased students' active participation, academic achievement, and on-task behavior during whole-class, math instruction. Rather than having one student participate at a time, all the students participated at the same time in answering questions. In addition, the teachers began asking more questions of the students than they did when they were not using the response cards, which promoted more active engagement with the students on math topics.

Meeting the different academic needs of students in the area of math can be challenging. However, today many online resources can be very valuable in assisting teachers in meeting their students' needs. One study done on 125 Massachusetts fourth grade students in three rural school districts showed that there was statistically significant gain in students' test scores after using a particular web-based mathematics tutoring system called 4MALITY to teach math problem solving (Maloy, Edwards, & Anderson, 2010). Seventy percent of the students improved their performance from pre-test to post-test. The researchers suggested implementing "structured practice and creative exploration of math problem solving using a creative blend of online and in-person learning activities." Other ways that teachers can meet the diverse learning needs of their students are by doing open-ended investigations, tiered tasks, or spiraling-scaffolded tasks so that students can attempt problems of easier or more difficult levels depending on their own capabilities (Kobelin, 2009).

Teachers, along with the strategies and method they use, have a big impact on a students' understanding of math. However, the students themselves and their attitudes also affect the outcome of math scores. Many students believe that mathematical talent is innate and that the effort one exerts in trying to learn it does not make much difference (Lewis, 2005). Therefore, they do not put much effort into trying to learn mathematical concepts or procedures, thinking that such effort would not benefit them in any way. An attitude like this can be an obstacle to learning; therefore teachers should begin instruction at the knowledge level of their students so that students find success in solving problems and gain confidence in their ability to do math. Teachers can then improve

their students' understanding by building up the conceptual knowledge of mathematical principles which govern the world.

As one can see, developing a strong math program involves many factors. It is helpful for teachers in planning lesson material and presentation methods to have time to collaborate with other teachers regarding the issues they face in teaching math (Lewis, 2005). Educators have found many programs, strategies, and teaching techniques that have been effective in helping students succeed in learning mathematical concepts and applying them. As teachers collaborate with one another, they can share methods and techniques that have worked with their students. They can also share resource ideas that assist in helping students understand. They can also be encouraged just in knowing that they are not the only ones dealing with difficulties in helping students learn math concepts. The task of improving a school's math program is multi-dimensional and there is not one simple solution that will solve all the problems. Collaboration is an important factor in discovering the difficulties in a particular school and then developing a plan to improve the program. It is important that all areas of the school's math program be evaluated and then a plan with a balanced approach must be developed and implemented to strengthen the program.

Definition of Terms

Contextualized math instruction. Instruction which provides students with life related mathematical problems that are not explicitly stated or structurally formulated as opposed to instruction which uses mathematical problems where the pertinent information needed to solve them is given to the students.

Curriculum map. A plan and schedule for teaching the entire subject's standards and content during the academic year.

Formative assessment. Activities, usually not scored, which provide information to be used as feedback to modify the teaching and learning activities.

Manipulative. Tangible object that students use to help learn math.

Open-ended investigation. Opportunities for students to design and carry out an experiment and make informed decisions.

Response system. Device, either manual or electronic, which enables all students to respond to a question at the same time.

Spiraling-scaffolded task. A task of increasing difficulty assigned to students with the aid of individualized support.

Standard-based instruction. Instruction designed around guidelines on what is to be taught and a system for checking whether the students have learned the material along with a method to reinstruct those who have not learned.

Summative assessment. Activities which occur at the end of a learning unit to determine if the content being taught was retained.

Tiered task. A task designed with various levels of difficulty which allow the students to choose the challenge level at which they work.

Statement of the Problem

Recently some concerns have been expressed by parents, teachers, and administrators concerning the math program at Jackson Christian School. One of the parental concerns that has been expressed is that some students in middle school are not familiar enough with math facts to do addition without counting or to do multiplication

without difficulty. Another parental concern is that some students do not understand the concepts behind the math facts. One of the concerns that the elementary teachers have had is curriculum related. Because of their concern that the curriculum was too difficult for the students and did not explain things very clearly, three years ago the school changed the math curriculum to a program that included more emphasis on math facts and gave students a continuous review of concepts learned. One of the concerns of the administration is that the math scores of the junior classes on the ACT test for the past three years have been declining. In addition, a concern of some new families considering JCS for their students is whether or not JCS's math program would be a step down for their students since algebra is not taught as a course until ninth grade.

Scope of the Study

The study will look at the K – 12 math program at Jackson Christian School. It will examine the current curriculum, comparing it to the *Curriculum Focal Points* published by the National Council for Teachers of Mathematics and the Common Core State Standards for Mathematics. It will examine the teachers' math backgrounds and their instructional methods in teaching math as well as the content that they cover during the year and their beliefs about student capability in understanding and improving in math skills. The study will also look at the area of assessment, specifically how teachers assess their students as well as the student scores on standardized tests. The study will compare student scores on the Stanford Achievement Test and the ACT test for the past six years.

Significance of the Study

This study will help the teachers at Jackson Christian School develop a stronger math program so that students are well equipped mathematically to impact the world for Christ. Ideally the impact of the study will be reflected outwardly in improved scores on standardized tests and a strong presence of JCS students in math-related careers. On a less visible scale, students will have a better understanding of concepts taught and demonstrate more proficiency in procedural skills, which will better equip them to handle the everyday encounters with math related tasks. This study will also identify strengths that exist in the JCS math program and give suggestions for possible ways in which to make improvements.

Methods of Procedure

Research Question.

What are the strengths of the math program at Jackson Christian School and what improvements can be made in order to better equip students mathematically to impact the world for Christ?

In the area of curriculum, the study will look at the course objectives and course outlines for each grade at Jackson Christian School and compare them with the *NCTM Curriculum Focal Points* and the Common Core State Standards for math. A comparison will also be made of the high school's math course outlines to the *ACT State Match Michigan Content Standards and Expectations* (2008) which lists the knowledge and skills necessary for students to be ready for college level work. The study will reveal whether the teachers are covering the material deemed essential for each grade and subject.

The study will also examine student math scores on the Stanford Test for students K – 9 and on the ACT/MME (Michigan Merit Exam) for the 11th grade students over the past six years. The analysis of the Stanford scores will give the results for three years while the school was using the Scott-Foresman curriculum (2006 – 2008) and for three years while the school was using the Saxon curriculum (2009 – 2011). An analysis will be made on each class' progression in math over the past six years to see if there was a pattern in scores. Was there a steady increase in growth of scores over the years? Was there significant improvement in some years? Was there a decline in scores? An analysis will also be made on each teacher's class results for the past six years. The analysis will give an indication of the student understanding in each particular teacher's class of students for the past six years. For the K – 9 grades, the study will examine scores only of students that have been in Jackson Christian School exclusively for the past six consecutive years so that the influence of other schools besides JCS will not confound the data one way or another. For the high school, the study will analyze the ACT scores of the entire junior classes. The school has a large influx of students each year in the 9th grade when the high school curriculum begins, and including all the students exposed to the high school math will give a better picture of the effect of the program rather than just looking at the small number of students that have been at the school six consecutive years.

The study will include surveys of teachers to determine their beliefs concerning teaching math as well as surveys of parents and alumni to determine the perceived effectiveness of the math program. The survey tool that will be used to determine the teachers' beliefs about how students learn math, their beliefs about the stages of learning

in math, and their beliefs about how teachers should teach math will be an 18 item Likert-type instrument entitled Mathematics Beliefs Scale, which was designed, adapted and revised by researchers Fennema, Carpenter, and Peterson (1987). The school's email system will be used to contact parents and alumni for their input. Parents will be asked what they perceive to be the strengths of the math program as well as the challenges that their students face in learning math. The parents will receive a questionnaire through email with some open ended questions as well as some statements regarding the math program at JCS to which they will respond on a five point Likert scale ranging from Strongly Agree = 5 to Strongly Disagree = 1. The alumni on the school's email address list will be asked which math courses they took in high school and how well they felt they were prepared for college math and for everyday math problems they face in life. Participants will rank their preparedness on a scale from 1 to 10 with 1 = Not very prepared to 10 = Very well prepared. In addition they will be asked what they felt were the strengths of the JCS math program and what they perceived to be some of the weaknesses. Because the responses to the parent and alumni questionnaires will be voluntary, there may not be a large return. Furthermore, the results may come mainly from participants who are either highly supportive or highly critical of the JCS math program. Nevertheless, the questionnaires may give some key insights into both the strengths and weaknesses of the program.

Lastly, interviews will be done with each of the K-12 teachers, the building principals, and the administrator of Jackson Christian School regarding the math program. The teachers will be asked to discuss the curriculum that is covered and the amount of time that is spent on topics during the year as well as instructional methods

and strategies that are used in addition to assessment methods. Teachers will also be asked about their strengths and their challenges that they face in teaching math. They will also be asked about the change in curriculum three years ago and the benefits or difficulties that they have found with the new curriculum. The building principals will be asked what they see as the strengths and challenges that they see in the math program as well as input that they may have received from the school community or the community at large about the Jackson Christian School math program. Before the interviews, the teachers, principals, and administrator will be given a copy of the interview questions so that they will have some time to think about their responses to the questions before the interview.

After all the data has been collected and analyzed, the study will compile a report of the strengths of the Jackson Christian School math program in the areas of curriculum, teachers, teaching methods, assessment, and supports. In addition, the report will indicate the challenges that exist in the math program at JCS and give possible suggestions for improving the program based on studies and research projects that have been done in the area of teaching math.

Results

A review of the credentials of the faculty at JCS revealed that one of the strengths of the math program at JCS is the fact that the teachers are well qualified to teach. All of the faculty that teach math, either as a full teaching schedule or as a course within their teaching schedule, hold at least a Bachelor's degree plus additional hours of continuing education. One of the elementary teachers majored in math in college. The high school math teachers both majored in math in college and have completed all but two credit

hours in their Master's degrees in Education. The middle school teacher who was teaching during the years of this study majored in Elementary Education and has a Masters in Christian Education Administration. The present middle school teacher holds a minor in mathematics. In the elementary, two of the teachers hold Master's degrees, one in Early Childhood Education and one in Learning Disabilities. Every year all of the teachers are involved in professional development courses and attend either the Association of Christian Schools International (ACSI) conference or else in-house sessions to improve teaching methods and strategies.

Not only is the faculty well qualified to teach, but they also have many years of experience in teaching. In the elementary grades, the range of teaching experience is between 7 and 32 years, with the median being 18.5 years. In the middle school, the present math teacher has 2 years of experience from teaching at a different school, but the previous middle school math teacher had 30 years of teaching experience, 23 of those years being at JCS. The two high school math teachers have each been teaching 25 years and 35 years respectively, all of them at JCS. The average number of years of experience for the math teachers at JCS is 23. Of the 206 combined years of teaching experience for the JCS math teachers, 186 of those years have been at JCS, which represents 90% of their teaching experience. This dedication has created a consistency in the staff and provided a strong continuity in the academic program.

Because the teachers are a veteran staff that have worked together for many years, they are very familiar with the curriculum and the academic program at JCS. They know each other's strengths and weaknesses, as well as the needs of particular students and classes that pass through the school. Teachers know the difficulties that classes have

with understanding math concepts and they are able to address those issues from the beginning of the year rather than having to wait for those problems to be revealed throughout the year.

Overall, from the teachers' perspectives, the classes seem to understand the math concepts that are taught and are able to do the procedures involved in solving problems. Teachers were asked on a survey to indicate whether their students never, sometimes, frequently, or always understand math concepts and procedures taught. Generally, the teachers indicated that their classes as a whole either frequently or always understand the concepts and procedures taught. The teachers also indicated that the students master the basic grade level math facts well and are able to solve math word problems.

In teaching mathematics, the teachers appear to have a good balance between teacher-directed instruction and discovery learning. In the elementary grades the teachers employ a lot of manipulatives and hands-on activities in teaching math concepts, which encourage the discovery learning for students. The early elementary grades use learning centers and games, as well as songs and activities like a bake sale, with the responsibility of working a cash register and making change, to help students learn to apply math concepts. A large variety of manipulatives are used in all the elementary grades. These include items such as snap cubes, blocks, square tiles, teaching clocks, and play money. For learning concepts related to measurement, some of the instruments the students use are rulers, compasses, protractors, 3-D geometric shapes, thermometers, and scales. In learning about fractions, students use fraction bars and fraction circles to help them understand the concepts.

Some of the activities that the elementary teachers use to help students learn math concepts are games. These games are located on the computer or are part of the Saxon math curriculum that is used in the classroom. Students can choose to do activities during math center time or during their free time. Other tools that the teachers use to teach math concepts are the Internet, with its wealth of information, pictures, and activities, as well as the classroom SmartBoard, with its many pre-designed objects, tools, games and activities. Other activities that the elementary teachers use to develop mathematical concepts are the investigations which are embedded in the Saxon math curriculum.

The middle school and high school students are also exposed to manipulatives, especially in the area of measurement when finding surface area and volume and when working with angles, triangles, and circles. In addition, the middle school (and the high school in a limited way) uses a math game called Tivitz to help students improve their computational skills as well as improve their logical thinking about math concepts. Recently, the middle school began participating in an annual State Tivitz tournament to help students improve their math skills. In the 2011 competition where approximately 200 students competed statewide, JCS students placed first in 6^{th} grade, second in 7^{th} grade, and first in 8^{th} grade. The middle school also has had unique opportunities for students to apply mathematical concepts through a Lego League program where they compete with their Lego robotic creations they design. In addition, the middle school has studied renewable energy and wind turbines which are located on the school campus.

Teachers also employ technology in their classrooms as they use SmartBoards to assist them in representing shapes and graphs more accurately. They also use the

SmartBoards to do simulations and learning activities that help students understand concepts better. Each classroom has Internet access and a projector which can transmit information onto the SmartBoard so that teachers can access data, information, and teaching tools on the Internet and interact with them with their students. In the high school, students use graphing calculators extensively in the higher level classes to analyze equations, matrices, and graphs as well as assist in complex calculations of functions and relations. The middle school and high school classes also have access to clickers, which are used in conjunction with the Smartboard and are very helpful in engaging students in thought and dialogue as concepts are reviewed or introduced. Each student has his own clicker with which he responds to a multiple choice question. Answers are tallied and then can be used as a point of reference for discussion or as a tool of assessment.

In the high school, the teachers place a strong emphasis on the big ideas in math and how the ideas are connected to each other. Teachers encourage students to think about the concepts that are applied when solving and about the multiple ways in which particular problems can be solved. The teachers also seek to engage the students in the learning process through whole class discussions as well as small group discussions in problem solving. In addition, teachers pair students together to work on concepts and then share with the class the thinking behind the procedures they used in solving problems. Through this method, students are able to solidify their thinking process and gain experience in explaining the process to another person, as well as be exposed to alternative methods of solving. As students work on practice problems, they are encouraged to work with others so that they can more readily clarify concepts and correct

errors in solving. In the high school, a lot of interaction takes place between students and between the students and the teacher in the process of learning math concepts and procedures. Sometimes lessons are taught by concept attainment, where students examine examplars of a concept to identify patterns and common characteristics. As students then analyze their thought process in formulating the characteristics of the concept, they are able to clarify the concept and eliminate misconceptions which may have developed.

Students that appear to be struggling with concepts are given individual help or small group instruction, both in the elementary grades and in the middle school and high school. In the elementary, if there is not enough time during class to help students struggling with math, help is given at recess time or after school. The teachers in the upper elementary grades require corrections or remediation on work that is below 70% so that students learn the concepts that are being taught. In the high school students are encouraged to correct assignments when the missed problems indicate a gap in understanding concepts or procedures. The middle school and high school have a half hour period every Wednesday morning before school when students can get help on their math homework if they need it. Much time is spent after school also helping students that need additional clarification of concepts or procedures.

Once students reach the high school, they begin a formal course in algebra and have the option of taking two different tracks of math. Students that find math rather challenging are able to take algebra and geometry classes that present concepts at a slower pace and with less rigorous problems than the regular math classes. Most of the students take the regular classes, but the slower-paced option is nice for both sets of students. Those that need more time in grasping concepts are able to learn without being

intimidated by those who rapidly grasp concepts, and those that rapidly grasp concepts are able to advance without being held back by those struggling to understand. Sometimes students just need an extra year or two with more individualized instruction in order to develop their mathematical processing skills so that they can maintain pace with more mathematically gifted students. Many students that enroll in the slower paced algebra class their freshman year switch to the regular geometry class their sophomore year and then continue on the regular track. Sometimes students begin the regular track and find out shortly into the year that it is too difficult for them and they switch immediately to the slower paced course. The flexibility of the program is very beneficial for the students, especially since both tracks are offered the same hour for students.

Another support that the high school offers to students is a Math Lab class where students work on their math homework each day and get extra instruction and help in understanding concepts and procedures, not only for their particular lesson in their math class that day but also for any area of weakness that is seen in that student's math understanding. In addition the school offers a Senior Math class which reviews all the math concepts taught in the algebra and geometry classes. This class gives students opportunities to refine their skills in these areas, solidify the concepts in their minds, and get a better grasp on the big ideas and connections that exist in the areas of math. This class is also a benefit to students that want to improve their ACT scores by retaking their ACT examination during the year.

JCS also strives to meet the needs of students that are strong in math. In the high school, a full range of math courses are offered to students. Besides Algebra I, Algebra II, and Geometry, the school offers Trigonometry, Pre-calculus, and Calculus. Students

also have the option of taking some math classes on-line from colleges as dual enrollment courses. Other courses that JCS offers which are heavily math based are Physics and Chemistry. The high school also encourages students to prepare and compete in an annual math competition in the areas of algebra, geometry, pre-calculus, and calculus. This competition takes place each year on the east side of the State and involves around 400 students from different schools.

As students pass through JCS, they have the opportunity to learn from teachers with different approaches to math. Some teachers believe that students should learn math facts before understanding the concepts behind them; whereas others believe that students should understand the concepts before they learn the math facts. Some teachers believe that students should master math facts before solving simple word problems; whereas others believe that students should solve simple word problems even if they have not mastered the math facts. Regarding word problems, some teachers believe that students should be shown how to solve simple word problems; whereas others believe that students will learn best by encouragement to find their own solutions to problems and discover mathematical relationships themselves. As indicated earlier, research shows that both methods have particular value, and each school of thought has been shown to significantly raise student assessment scores. Therefore, having teachers on both ends of the spectrum in their approach to teaching math exposes students to different teaching styles and gives students the opportunity to learn within their own preferred learning style some years and be stretched in other years. Regardless of the teacher's belief about order or method of instruction, all the teachers agree that specific procedural techniques need to be explicitly taught to the students. This belief provides a consistency in methodology

concerning procedural information. Regarding the timing of the presentation of concepts, the format of the current math curriculum in the elementary provides a consistency in the order of presentation. In every lesson, teachers review multiple old concepts as they introduce one new concept per lesson. Teachers proceed with the teaching of one new concept each day and the reviewing of old lessons unless they find numerous students are repeatedly missing review concepts which are foundational in importance. At that point, additional time is spent in addressing a particular area of difficulty.

A good math program at a school needs not only skilled teachers but also a good curriculum. In 2001 the school began using the Scott-Foresman curriculum. It appeared to have a good scope and sequence, many supplementary resources for teachers, as well as plenty of examples and practice problems for students. However, as the teachers used the curriculum, they found a few frustrations with it. The curriculum included many tidbits of interesting information and colorful illustrations, but those items sometimes were rather distracting to the students. Some teachers felt that there was too much stimulus in the book and not enough blank, white space on the pages to help identify the different concepts. Also, because the curriculum wanted to teach students how to look up data and facts, often the information that students needed to solve problems was located on a page in the back of the book, which made it somewhat difficult for students in finding the information they needed to solve their problems. In addition, the curriculum's large variety of problems for practice made it difficult for teachers to know which problems to choose to assign. On the other hand, there did not seem to be enough practice on the basic addition, subtraction, multiplication, and division facts that students need to know in order to solve problems. Furthermore, teachers were finding that often

the students did not comprehend or retain their math lessons and were frustrated with their math assignments.

To help students learn their math facts better, in 2007 the teachers supplemented their math curriculum with the program Mastering Math Facts. In the program, students studied their math facts and then practiced timed worksheets to gain proficiency in remembering their facts. Students were able to learn at their own pace. Those that learned quickly were encouraged to push ahead as much as they could and those that had more difficulty were able to take their time in mastering the facts without feeling hurried to catch up with others. There seemed to be a friendly competition among the students as they learned their math facts. The elementary teachers speak very highly of the Mastering Math Facts and noted a marked improvement in student work after implementing this program. The only negative comment that was made concerning the program during the teacher interviews was that the school did not have any explicit expectations which were communicated to parents and others regarding math facts that needed to be mastered in order to promote students from one grade to the next.

After the success with the Mastering Math Facts program, the elementary teachers began examining different math curricula to find one that would be more suited to their needs. In 2009 they adopted the Saxon math curriculum, and most of the elementary teachers were very excited. The first through fifth grades switched from the Scott-Foresman curriculum to the Saxon curriculum. The kindergarten class, however, continued to use the ABeka math program, which it had been using all along. The kindergarten teacher stated that the ABeka material for kindergarten would provide a better foundation for students than the Saxon program because it introduced more

concepts and it had more eye appeal with its color in its text, a feature that the Saxon curriculum does not use. The teachers that switched curriculum noted a change in the students' attitudes toward math. Students were more positive and excited about math after the Saxon curriculum was introduced. Students were finding success and building confidence in math class, and they were beginning to like math. The Saxon curriculum introduces only one new concept or part of a concept per day and continues to build on that concept all throughout the year providing much review on every concept. Students have multiple opportunities to understand the concept and as a result build some confidence in their ability to solve math problems.

One of the features that the teachers like about the Saxon curriculum is that it uses a lot of manipulatives in the early grades when students are beginning to formulate math concepts. Also, all throughout the curriculum there is a consistent patterning of problems, which makes it easy for students to recognize a concept and know how to solve the problems. The teachers especially like the spiraling review each day and the fact that students retain more knowledge. Students are constantly reviewing math concepts, geometry skills, and terms. They are also introduced to algebra concepts through patterns and symbols. Teachers also like the emphasis on word problems and the bigger variety of topics that are taught in a systematic way and reviewed frequently. Students are introduced to concepts like double digit addition, fractions, percentage, and measurement much earlier grade-wise than in the previous curriculum. Teachers also liked the fact that only one new concept is taught per day and there is not a lot of inconsequential material that teachers needed to sort through in order to determine what the essential concepts of the lesson are.

In addition, teachers like the fact that the assignments are predetermined and that they no longer have to choose which problems to assign. The Saxon curriculum gives 30 problems for students to do each day which include work on the new concept for the day as well as review concepts from previous lessons from throughout the whole year. Teachers like this format for homework because if a student does not understand the concept for the day he does not run the risk of missing every problem in the assignment but has many opportunities in the future to continue working on understanding the concept. The textbook also cites for students the page on which the concept is introduced so that they can refer back to the explanation given on that lesson. Another benefit from the consistent homework format is parents always know what to expect concerning assignments. There is no guess work as to what is assigned in math each day, and as a result, there seems to be more involvement from parents in making sure that students complete homework. In addition, the spiraling review of questions helps instill confidence in students as well as provides variety in homework problems. The students do not become bored with continuous repetition of the same kinds of problems in the homework. On the other hand, some students might benefit more from continuous repetition of concepts in order to fully grasp the concept or required procedure; however, overall it seems that an overwhelming majority of students benefit from the variety of problems and the continuous review than are hindered by it.

Though almost all of the elementary teachers adopted the Saxon curriculum and were pleased with it, some of the teachers in the early elementary grades did express a few concerns with the curriculum. Two teachers felt that the Saxon curriculum was not challenging enough for the students. As mentioned before, the Kindergarten teacher

continued to use the ABeka math because she felt that the Saxon math was too easy and was unappealing to students because of its lack of color. The First Grade teacher implemented the Saxon math but stated that because it was too repetitive and simple for her students, she added additional concepts to the first grade curriculum. Perhaps the curriculum seemed too simple for the students because of the strong foundation that was laid in the kindergarten class with the ABeka program.

The Middle School has continued to use the Scott-Foresman series since its implementation in 2001. At the present, the school is considering switching or at least updating curriculum. There is a strong consensus among the elementary staff that the middle school should adopt the Saxon math and provide continuity for the fifth graders that are transitioning to middle school, but the decision regarding a change in curriculum has not been made yet. The final decision will be made in the near future by the math department staff in conjunction with the newly hired middle school math teacher for the 2011 school year. In the High School the teachers use the Glencoe math curriculum, which is the successor to the Scott-Foresman curriculum, for all the classes except Calculus, which uses a Houghton Mifflin text. The teachers are satisfied with the curriculum with its scope and sequence and especially like the resources that are available in strengthening and assessing students' understanding of concepts. The texts themselves are not always user-friendly to the students, but there are many online demonstrations, explanations and extra practices available through the curriculum which can be very beneficial to students, especially if they are absent from class or they do not understand or else forget the concepts after class.

Regardless of the text that is used, teachers need to make certain that they teach the students the necessary concepts and the procedures that are needed to solve problems mathematically. The National Council for Teachers of Mathematics has identified three curriculum focal points for each grade Pre-kindergarten through eighth grade, and the State of Michigan has adopted a document entitled Common Core State Standards for Mathematics to aid teachers in focusing on "conceptual understanding of key ideas" and in "organizing principles . . . to structure those ideas" (Common Core State Standards, 2010). Because not every student learns at the same rate or masters the skills and concepts at the same time and because concepts can be applied in several content areas, making learning a continual process that is intertwined between many focus points, these focal points and standards are meant to be viewed as "major instructional goals and desirable learning expectations, not as a list of objectives for students to master (www.nctm.org)."

In order to evaluate the curriculum program at JCS, the math teachers reviewed the Curriculum Focal Points and the Common Core Standards for their particular teaching areas and compared them to the material they teach in their classrooms. The teachers indicated whether or not they addressed each particular standard in their classrooms. Considering the 27 curriculum focal points identified by the NCTM for Kindergarten through eighth grade, the JCS teachers indicated that they are addressing all but two of the focal points (or 93% of them) at the prescribed grade level. Along with the three curriculum focal points for each grade, NCTM has identified many related connections to other concepts which help form a comprehensive mathematics curriculum across the grades. Refer to Table A1 in the appendix to see which NCTM focal points

and connecting concepts are not covered in the recommended grades. However, all of the focal points and most of the connecting concepts that are not taught in a recommended grade are taught in a subsequent year.

The Common Core State Standards of Mathematics are more specific than the NCTM focal points. They itemize specific concepts for students to understand and practice, and they give examples to clarify what is intended in the standard. In Table A2 in the appendix one can see the percentage of topics from the Common Core State Standards of Mathematics that are taught by the teachers in the prescribed grade levels. However, the results in Table A2 must be interpreted loosely. In each grade every domain has a different number of standards within each cluster, and each standard does not represent an equal portion of teaching time throughout the year. Therefore, one cannot assume that if a particular domain had a low percentage of concepts covered within the standard that the students were missing a big portion of recommended instruction. In addition, a standard that is not taught in a particular year is most likely taught in a different year. Furthermore, the teachers indicated in their evaluations that sometimes the wording of the standards made it difficult for them to know precisely what concepts the standards were addressing, especially if an example was not given. Therefore, the teachers might be covering particular standards in their classrooms but just did not recognize the language used in the standard to identify the instructional goal. Table A3 (see appendix) identifies specific concepts from the High school Common Core State Standards that are not taught in each particular strand of mathematics. Tables A2 and A3 in the appendix indicate that while some topics are covered quite well in the grades that quite a few other topics are not introduced at the recommended grade level

and many are not introduced at all. This is a matter for investigation to consider whether or not adjustments should be made.

Teachers in all grades discern whether or not students understand concepts by doing both formative and summative assessments. Observation of student work, dialoguing with students about math, and seeing facial expressions are all methods used by teachers in formative assessment to discern whether or not students are comprehending concepts. Some of the teachers use response cards, projects, and self-assessment to do formative assessment. Other teachers do formative assessment by observing student responses to games. In addition, others use exit passes and clicker responses to do formative assessment. All of the teachers, however, look for reoccurring problems in student work as they do formative assessment. When difficulties are detected, teachers then intervene and give the students the remediation that they need in a particular area. Summative assessment is done mainly through tests in the elementary and through tests and quizzes in the middle school and high school.

Each year JCS participates in standardized testing. In the fall, the sophomores take the ACT PLAN Test and the juniors take the PSAT/NMSQT test. In the spring, students in Kindergarten through ninth grade take the Stanford Achievement Test (SAT) and the juniors take the Michigan Merit Exam (MME) which includes the ACT test.

The results of the Stanford testing in Table 1 show that during the 2006 – 2011 years, the average of each grade's scaled scores ranged between nine and 40 points above the national average. In the last two years, every class had an average math score above the national average. During the previous four years, six scores were below the national average. Four of the scores below the national average belonged to the Class of 2015, but

that class has shown continuous improvement over the years. During that class' third grade year the class was 18 points below the national average. In their fourth grade year the class was 10 points below. In their fifth grade year the class was seven points below, and in their sixth grade year only three points below. Finally in their seventh grade year the class crossed the line and their average was five points above the national average.

Table 1

SAT Scaled Average Total Math Scores for Grades K - 9

	K	1	2	3	4	5	6	7	8	9
Class of 2011			550	594	635	654	679	693	705	723
Class of 2012						656	678	699	707	729
Class of 2013						655	666	703	707	722
Class of 2014					647	655	671	699	708	726
Class of 2015				588	608	632	652	668	676	
Class of 2016			579	620	643	655	659	673		
Class of 2017		551	597	602	651	665	660			
Class of 2018		544	569	631	653	672				
Class of 2019		595	615	656	666					
Class of 2020		558	604	633						
Class of 2021	530	561	600							
Class of 2022	531	545								
Class of 2023	522									
JCS average 2006-2011	528	559	594	622	645	657	664	689	700	725
National Average	492	530	576	606	618	639	655	663	675	685
Comparison of JCS average to national ave.	+36	+29	+18	+16	+27	+18	+9	+26	+25	+40

Note. The bottom score in each grade column represents the 2011 score; the score above it represents the 2010 score, etc. The shaded scores indicate the years when Saxon curriculum was used. Adapted from "Student Reports Jackson Christian School," by Pearson Education, Inc., (2011). *Stanford Achievement Test Series.*

Comparing the JCS average math scores of individual classes to the national average math scores in Table B1 in the appendix, one can see that there is quite a bit of variation. From year to year, some classes stayed consistently about the same number of points above the national average. Others varied quite a bit in how much they were

above the national average from each year. The Class of 2017 made a big improvement in their scores when they went from being four points below the national average in third grade to 33 points above the national average in fourth grade. Likewise, each grade varied in how much the individual classes in that particular grade were above the national average, with some classes being well above the average and others just slightly above the average. However, the Class of 2019 consistently had average scores well above the national average. In 2008 the class was in first grade and scored an average of 65 points above the national average. In second grade they were 39 points above the average, in third grade 50 points, and in fourth grade 48 points.

Relating the scores to the curriculum that was used, the data in Table 1 shows that in 2008, just prior to the switch to the Saxon curriculum, three of the elementary classes scored below the national average; whereas in the three years after the switch to the Saxon curriculum no classes scored below the national average. Therefore, it appears that the switch in curriculum improved the students' understanding of math concepts and procedures. See Figure 1 for a comparison of the average math scaled scores for each grade before and after the Saxon curriculum was introduced. Caution should be used, though, in attributing the increased scores to curriculum alone. Observation of future scores should be made to see if the trend continues. Perhaps the increase in average class scores could be just because those particular three classes were inherently stronger in math. Even though the curriculum changed during the years of the study and an increase in scores happened, the same pattern of variety in scores surfaced. During these years, the teaching staff remained the same; therefore the only changing factors were the

curriculum and the class of students. Perhaps both factors strongly influenced the change in scores.

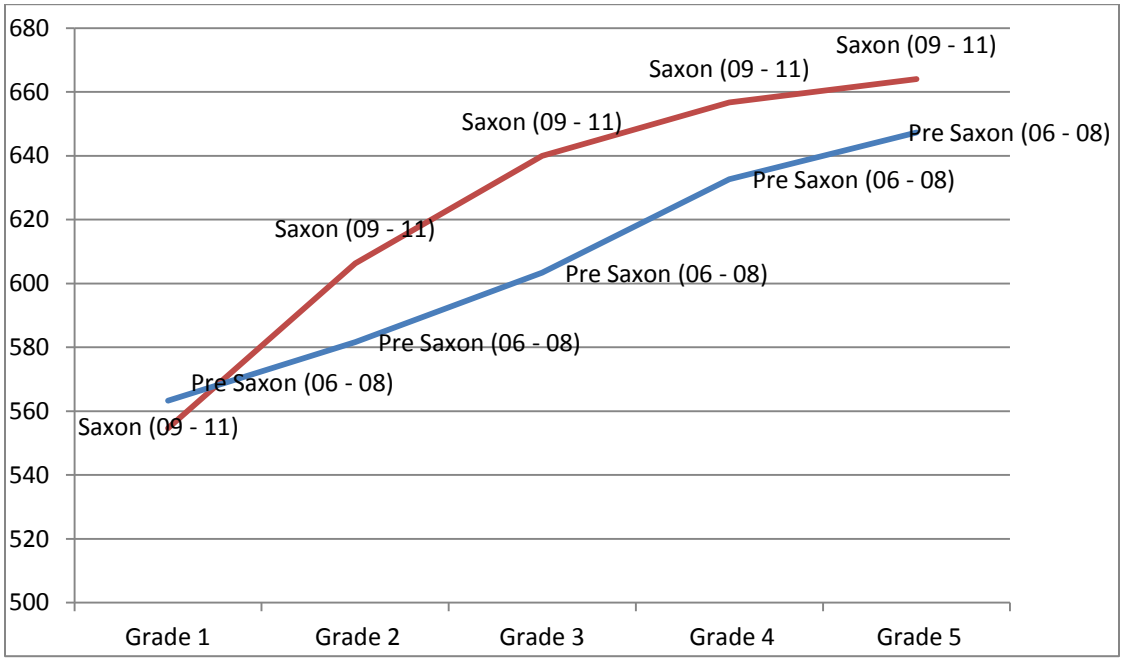

Figure 1. JCS Average Math Scaled Scores. Adapted from "Student Reports Jackson Christian School," by Pearson Education, Inc., (2011). *Stanford Achievement Test Series.*

With the Saxon curriculum, though, teachers felt more confident in teaching and students showed a more positive attitude about math and their abilities in math. Attitude plays a big part in motivation and accomplishments. Therefore, the Saxon curriculum seems to be a good factor for the math program at Jackson Christian School. Nevertheless, the staff should continue to evaluate the program, interpret the scores, monitor the progress, and collaborate with one another to make improvements and continue strategies that help students understand math concepts and perfect procedures while they grow mathematically in their knowledge and skill.

The Kindergarten teacher believes that the ABeka kindergarten curriculum is superior to the Saxon kindergarten curriculum. Therefore, she uses the ABeka math; whereas the First Grade teacher uses the Saxon math. The Kindergarten classes

participated in the testing only two years of this study, but comparing the scores of these grades as students transition from one year to the next, one can see in Table B1 (see Appendix) that the classes of 2021 and 2022 showed a decrease of 7 points and 24 points respectively in their position above the national average. It is premature to base a judgment of curriculum on this little data and the evidence of one test score a year but future consideration should be given to trends in scores as the math program is reviewed.

During the years for which the data was collected, the Class of 2016 had the same teacher in second grade and third grade. The first year with the teacher the class scored three points above the national average and the second year they scored 14 points above the national average. Having the same teacher for math two years in a row seemed to help the students gain a better grasp on math concepts and procedures.

Comparing the bar graphs of Figures C1, C2, C3 in the Appendix, one can see that the individual classes are fairly consistent in their achievements. If a class appears to do well in its beginning years, it continues to do well throughout the years. If a class appears to have a more difficult time, that pattern continues; however, as noted earlier the class with the most difficulty in achievement scores seemed to gain momentum over the years and improve in their performance. Therefore it appears that the teachers are helping the students continually improve and that the outcome of the scores depends much on the nature of the class and the abilities of students within the class in understanding math concepts and procedures.

One interesting result with the Class of 2017 was that the class had fairly average gains in scores during the years, but it had unusually large increases in scores during its

second and fourth grade years. Investigating results like this on an annual basis may reveal factors that would be beneficial to consider for improving math instruction.

Another interesting pattern occurred in the sixth grade classes. During the Pre-Saxon years when the students entered sixth grade, their scores increased about 20 points; however during the Saxon years, the student scores remained relatively unchanged during their sixth grade years. This is an issue that needs further investigation to determine whether the decline in achievement is due to curriculum, since the sixth grade program does not continue with the Saxon math but uses the Scott-Foresman math, or due to other factors.

Another interesting pattern occurs in the seventh and eighth grade classes. Even though the classes both scored well above the national average, the seventh grade classes all have a natural gain in scores, but the eighth grade classes have a very minimal increase in scores. This pattern, too, is a matter for further investigation.

In addition, another matter for investigation is the reason why Jackson Christian School's percentile ranking of math scores on the Stanford testing is relatively low for each grade compared to other Christian schools in the Association of Christian Schools International (ACSI). This pattern is seen not only in math but for the most part in all academic areas. In fact, the percentile ranking in relation to ACSI schools is always lower than the percentile ranking compared to all the school nationwide. Table 2 shows the comparison of the percentile ranking of JCS students to students in other Christian schools in the association as well as to students nationwide which took the Stanford test.

Table 2

Comparison of JCS Percentile Rankings for Stanford 2011 Scores

	Math		Reading		Language[a]		Spelling[b]		Science[c]		Social Sci.[d]	
Grade	Nat. PR	ACSI PR	Nat. PR	ACSI PR	Nat. PR	ACSI PR	Nat. PR	ACSI PR	Nat. PR	ACSI PR	Nat. PR	ACSI PR
K	73	41	82	36	-	-	-	-	-	-	61	36
1	63	34	66	36	85	63	67	32	-	-	75	59
2	64	39	62	35	75	51	63	43	-	-	74	62
3	72	47	66	41	68	44	65	42	64	42	64	41
4	78	59	76	52	71	41	70	47	73	52	70	44
5	78	52	74	48	84	63	75	54	66	40	71	41
6	57	28	52	25	42	19	50	27	48	23	48	24
7	54	22	58	30	56	30	55	31	50	29	45	22
8	59	28	55	26	55	27	50	24	58	35	55	28
9	79	57	75	53	68	45	70	50	73	60	74	61

Note. PR = percentile ranking; Nat. = national; ACSI = Association of Christian Schools International. [a]Language test not given in Kindergarten. [b]Spelling test not given in Kindergarten. [c]Science test not given in Kindergarten, 1st, and 2nd grades. [d]Social Science rankings for Kindergarten, 1st, and 2nd grades are for the area entitled "Environment." Adapted from "Group Reports Jackson Christian School," by Pearson Education, Inc., (2011).

The standardized testing that is done in the high school is the ACT test, which the juniors take. The ACT is a curriculum-based assessment tool designed "to measure the skills high school teachers teach and instructors of entry-level college courses expect" (ACT Profile Report). The ACT reports college readiness benchmark scores which are "minimum scores needed on an ACT subject-area test to indicate a 50% chance of obtaining a B or higher or about a 75% chance of obtaining a C or higher in the corresponding credit-bearing college course" (ACT Profile Report). The benchmark score for college algebra is 22. Table 3 shows that during 2006 – 2011 JCS mathematics scores did not reach the ACT benchmark of 22, but neither did the state nor the nation as a whole.

Table 3

Comparison of Average JCS ACT Mathematics Scores with State Scores from 2006–2011

Graduation Year	JCS	State	Nationwide
2007	20.7	21.3	21.0
2008	21.1	19.5	21.0
2009	20.1	19.6	21.0
2010	20.9	19.7	21.0
2011	19.7	19.9	--
2012	21.6	19.6	--

Note. Adapted from ACT High School Profile Reports.

Looking at the average composite score for math can be one indication of a school's achievement in the area of math. However, looking at an average does not show the individual achievement of students and progress that is being made. The ACT Profile Report each year divides the students' scores into seven categories and indicates the percent of students that score in each category. Looking at Table 4, one can see that nationwide the biggest percent of students falls in the 16 – 19 range; whereas the biggest percent of JCS students falls in the 20 – 23 range. Though JCS does not have even 1% of its students in the top range of 33 – 36, it does have a larger percent of students in the top half of the scoring range than the bottom half. One can also see a definite shift in the placement of the scores of JCS students. Even though the 2011 JCS composite math score did not meet the benchmark score of 22, an examination of the categories where the individual scores fell reveals that less students are in the lower brackets and more students are in the higher brackets than in previous years. In fact 0% of the JCS students

were in the bottom two ranges during the last year of testing. This indicates that individual scores are improving and that there is a positive shift overall in the scores.

Table 4

Percent of JCS Students in Each ACT Math Scoring Range

Class	Year Tested	Score						
		1 - 12	13 - 15	16 - 19	20 - 23	24-27	28 - 32	33 - 36
JCS 2009	2008	0	10	38	30	23	0	0
Nationwide		2	25	37	16	13	6	2
JCS 2010	2009	0	14	31	38	14	3	0
Nationwide		1	24	36	17	12	7	7
JCS 2011	2010	0	13	30	33	17	7	0
Nationwide		1	22	36	17	15	7	2
JCS 2012	2011	0	0	30	37	19	11	0
Nationwide		--	--	--	--	--	--	--

Note. Adapted from ACT High School Profile Reports.

Further investigation reveals that students in the last two years who took one or both of the upper level classes of Trigonometry/Pre-Calculus and Calculus were more than adequately prepared to do well in college math. The scores of those students were above the math benchmark of 22. Many of the scores were well above the benchmark. See Table 5 for scores for students in the upper level math courses.

Table 5

ACT Math Scores for JCS Students in Upper Level Math Courses

Graduating Year	Highest score	Average Score
2011	28	24.3
2012	31	26.3

Note. Adapted from ACT High School Profile Reports.

In teaching students mathematical concepts and procedures, teachers identified several concerns. One of the most challenging areas was solving word problems. In the elementary the biggest difficulty seemed to come when word problems were stated differently than the ones in their text. Students got used to a format and a particular wording in problems in the Saxon program and had a hard time seeing what to do when similar problems were presented in a different format with different wording, especially on standardized tests.

Elementary teachers also expressed a concern about not having enough time to do a lesson a day, as prescribed in the curriculum guide. Some lessons involve an investigation which takes more than one day to complete. In addition, some teachers expressed a concern about how to get slower students to speed up on their work and processing. On the other hand, some teachers expressed concern about getting students to slow down as they worked to pay better attention to details. Another concern of the elementary teachers was that students who transferred to JCS mid-year had a hard time completing assignments because many different concepts appeared each day in the spiraling review. The biggest concern in the high school was the few students who often did not complete homework in a timely manner which affected their understanding and development of mathematical thinking.

A survey was emailed to the parents of the student body regarding the math program at JCS. Parents were given the option to do a simple reply to the email or to mail back a response anonymously. Out of the approximately 200 surveys, 25 parents responded. Some parents were new to the school and had had students in the school only one year; others were well acquainted with the school and had had students in the school

over a span of 14 and even 20 years. The median number of years the respondents had had students in the school was six years. See Table 6 for a tally of the parental response to the questions asking parents to rate different aspects of the math program on a 5-point scale. Parents were given the option of not rating an area if they were undecided, and therefore some areas did not get a rating from some parents.

Table 6

Parental Response Regarding Emphasis Placed on Math Topics at JCS

Topic	Not nearly enough 1	Needs a little more 2	Good amount 3	A little excessive 4	Way too much 5
Amount of work your students do	1	2	18	4	
Learning math facts (add, subt., mult., divide)	1	4	17	1	
Knowing procedural skills (steps in solving problems)	3	12	10		
Solving word problems	3	11	10		
Knowing the concepts of what is happening when solving problems	4	11	8	1	

The message that was communicated from the parent survey, in both the 5-point rating scale and in the short answer response questions that were asked, was that more emphasis should be placed on procedural skills, solving word problems, and understanding concepts when solving problems. In the response to the short answer questions, parents repeatedly cited the area of word problems as a difficult area for students. Other areas that were cited as being difficult for students were working with fractions, solving geometry problems, finding perimeter and area, and finding common

factors. In addition, some parents indicated that more explanation was needed on procedures and developing the concepts behind the problems and that more guided practice for students in the classroom was needed before sending them home to do homework.

One of the strengths of the math program which was cited by numerous parents was the Mastering Math Facts program in the elementary. Parents liked the fact that students were able to progress at their own speed in mastering the facts and that there was a fun, competitive atmosphere among the students as they worked on learning the facts. Another aspect of the math program that received high ratings from the parents was the Saxon math curriculum. Parents thought that there was a good emphasis on solving word problems in the series. They also liked the fact that the series gives step-by-step instruction for new procedures and gives a lot of review and repetition of concepts all throughout the curriculum so that students retain the concepts and continue to build on them rather than having to relearn them each year. Some parents however felt the Saxon curriculum did not give enough practice on concepts for students to master the material before reviewing it, which made homework time frustrating with a review of many half-learned concepts.

Another strength of the math program, which was also repeatedly mentioned by parents, was the faculty of JCS. Parents appreciate the knowledgeable faculty who teach the lessons well and are able to teach and communicate effectively with all levels of students. Parents also noted that the faculty are always willing to spend time extra time with students in class and out of class to help them learn and understand concepts and procedures.

In addition, parents appreciate the extra opportunities that are available to help students grow and expand in their knowledge of mathematics. The middle school meets one day a week to work on real world problems that help them apply mathematical concepts. For several years the middle school students worked with the Lego League competition designing robots which could accomplish a given challenge. Presently the students are studying options for renewable energy and specifically wind turbines, which are located on the school campus, and the data that is obtained from them. Students then design their own wind turbines and test their functionality.

Parents also appreciate the attention that is given to students that need extra support in learning math concepts and procedures. They mentioned specifically the availability and willingness of the staff to help students outside of class and to provide extra credit opportunities to those who spend extra effort improving their skills. The parents also appreciate the Senior Math Review class that is offered to students their senior year to help students master concepts that perhaps they did not fully understand the first time they were exposed to them. The class also provides an opportunity for students to review concepts in preparation for college testing programs such as entry level math placement or the ACT test which many students retake during their senior year to try to improve their score.

A survey was emailed to some of the graduates from the past four years. Sixty-three alumni email addresses were available, and from them ten alumni responded. Half of the responses were from alumni that had taken all the advanced math classes that JCS offers and half of the responses were from alumni that had taken only the required classes. For some alumni the required classes were only Algebra I, Algebra II, and

Geometry, but for others it included also the Senior Math Review class. All of the alumni indicated that they felt well prepared for the math they needed in everyday life and in college. One of the alumni, however, failed her math class in college, but she said that she knew JCS did a good job preparing students and that she did not focus in high school and avail herself of the education that was given her. Another alumnus stated that her math training helped her get accepted at the U.S. Army Chemical Biological Radiological and Nuclear School. Another alumnus stated that his start in one of the math related classes, accounting, peaked his interest in that field and he plans to graduate this year with a degree in Accounting and be a Certified Public Accountant.

The alumni stated several things about the math program that they felt helped them while they were students. Almost all of them stated that working with other students on problems really helped them understand math better. They also mentioned that the teaching was very effectively done and that listening in class was extremely helpful in understanding the concepts. In addition, the extra one-on-one instruction that they received from the teachers was very helpful. The alumni also mentioned that reading the text, taking notes, doing extra problems, and making corrections on assignments were helpful in giving them a better understanding of the math concepts and procedures.

Over half of the alumni responses stated that one of the strengths of the math program was the teaching staff at JCS. They noted specifically the kindness and patience of the teachers in working with the students. They stated also that the lessons were taught well in a clear and concise way and that the question and answer time in class was very helpful, especially with the more difficult problems. Others cited one of the

strengths as being the fact that the class sizes were small, allowing more individual attention and help when needed. Others cited the Senior Math Review class as being like a capstone class that helped put everything together for them.

One of the concerns that an alumnus saw in the math program was an incident that occurred the year that Algebra II became a requirement for all students. That particular year, because of scheduling issues, not all of the students who found math challenging were able to register for the slower-paced Algebra II class. As a result weaker math students were in the same class as the students that were preparing for the higher math classes in college. That year both sets of students were frustrated in the class. Another concern that was mentioned by an alumnus was that the teachers' kindness and leniency with the students might have enabled the students to get too far behind on assignments. In addition, having the answers at the back of the book, as math books usually do to help students know whether or not a problem was done right, was a temptation to be dishonest and just write down the answer without figuring out how to do the problem. Finally, one other alumnus stated that he thought the students should be encouraged and required to read the math text more because in college one needs to be able to read the math textbooks.

Overall the math program at JCS seems to be heading in the right direction. The teachers are adequately prepared to teach, and they have refined their teaching skills through many years of experience. The student scores on the standardized Stanford tests are above the national average. Within the classroom, teachers use a variety of teaching techniques and manipulatives to aid understanding. Teachers also monitor student progress and give individualized attention to students that are struggling. Parents are

appreciative of the teachers and the education that their students receive at the school. Furthermore, graduates are adequately prepared mathematically to pursue their goals and enroll in further education.

At the present, JCS seems to have a very good math program. However, there are a few areas that could be strengthened to produce an even better program. In the area of curriculum, the teachers need to make sure that all of the topics in the common core standards for each grade are taught each year. In addition, results from the standardized testing should be reviewed at the end of the year by teachers to determine which areas presented difficulty and which areas need to be reviewed more aggressively in the following year. One tool that would be helpful in making sure that all of the curriculum topics are taught is a curriculum map. Outlining which topics (or lessons) will be covered each month will help teachers budget their classroom time and not get too focused on some concepts at the expense of other concepts.

At the present, some of the challenging areas for students are fractions, data representation, surface area, volume, probability, and the application of concepts in word problems. To strengthen the math program, the school should consider introducing adding and subtracting mixed numbers with like denominators as well as the multiplication of fractions as early as fourth grade, as stated in the common core, and then continue to reinforce and build on these concepts each year so that students are proficient in these areas before ninth grade. In addition, the school should consider a stronger emphasis on surface area and volume beginning in the fifth grade. Likewise an exposure to data representation of frequency tables, bar graphs, and line plots would aid students in reading and interpreting data. In the high school, comparing the curriculum

with the State's match of content and expectations relating to the ACT readiness benchmarks, one can see that the students need more work with probability and statistics. In addition, in order to align better with NCTM standards high school teachers should give the students more practice in explaining and proving answers. Providing more opportunities for students to be involved in cooperative learning activities, discussions, and constructed responses would help students better understand and be able to articulate concepts and how they relate in the problem solving process.

Over the years, the school has done several things to help students that struggle in math. Besides giving individual help to students each year, the school has established a math lab class which gives high school students the opportunity to enroll and receive help each day on math assignments or on areas of weakness in math. In addition, a senior math review class is available for seniors to review the high school math concepts and prepare for college testing of math skills. Other options which the school could consider in improving student proficiency in math are the many free online math games and activities or even the computer-based skill-developing program entitled *Accelerated Math*, which research has shown to be very beneficial in developing and strengthening math skills in students. This program could be used with all students, grades K – 12. It identifies a student's level of proficiency in math and gives practice questions tailored to the student's needs in order to move the student to higher levels of proficiency.

Another factor that could strengthen the math program is an intentional, continual development of a positive attitude toward math in all students. Some students are reluctant to apply themselves to understanding math because they think that they will never understand and that it is no use trying. Teachers could foster an even more positive

attitude in students by scaffolding tasks. They should make sure that students are comfortable with the vocabulary of math and the way in which math ideas are communicated through symbols. They should provide students with the support that they need to do the problems—whether that would be with a graphic organizer that helps them understand, a study buddy that is able to answer questions as they arise, manipulatives that help them understand, or other tools that would assist in comprehension and solving procedures. Furthermore, frequent formative assessments should be made so that both student and teacher know whether or not the student understands the concepts and is able to apply procedural skills correctly. Teachers could also provide tiered tasks in which students can choose to do easier, average, or harder problems, according to their ability. In that way the student's knowledge of concepts can be assessed, but at the same time students can build confidence at an easier level and then branch out into harder areas as their understanding develops.

Although high standardized test scores are honorable and desired as one measure of student proficiency, they do not tell the whole story of what happens in the math classroom. They are a snapshot of student understanding at one particular time during the year, and even then, for a variety of reasons, some students may not be able to demonstrate their proficiency that day. Therefore, many other things should be considered when evaluating a math program. For example, are students growing in their math knowledge and skills? Are they being equipped with the math skills necessary to function and make good decisions mathematically in everyday life? In addition, are they being taught the math skills that go beyond the everyday math skills since they do not know which skills they will need later in life to do the tasks God calls them to do? Not

every student is designed by God to excel in math, but all students should be encouraged to develop their math knowledge to the best of their ability. Students should be encouraged to do their best and be pushed to attain the highest level of understanding that they are capable of achieving.

On the other hand, some students are able to learn math skills rather easily when they apply themselves. A strong math program will attract the attention of these students and engage them in learning and increasing their knowledge base and skills. One way the school could foster a better development of math abilities of students is to begin offering two levels of math in the eighth grade rather than waiting until ninth grade. In the eighth grade some students are still struggling with the basic operations with fractions, decimals, and percents; whereas, others are ready to move into more abstract concepts. The students that need extra review with the basics could refine their skills and students that are proficient in math could move more rapidly through the curriculum and delve deeper into a broader variety of topics. This could improve the math scores of the eighth grade classes since presently there seems to be little growth between the seventh and eighth grade years. Also, it would give students a stronger foundation in preparing for algebra related content. Then in ninth grade with a stronger skill base more students would be prepared for the rigors of algebra and able to pursue a broader range of topics and examine concepts at a deeper level.

Another suggestion for improving the skills of those that excel in math is to encourage students to be involved in competitions which will challenge them to use their math knowledge and to think creatively and accurately about math concepts. Some

competitions involve pencil and paper tests; whereas others involve the challenge of designing something that requires the application of many mathematical concepts.

Another way to strengthen the math program would be to provide regular times for teachers to collaborate with each other about their math classroom. As teachers share the difficulties and successes they are having with the curriculum and students' understanding, they could glean successful ideas from others that could help them in their classroom. Another possible consideration would be a team teaching approach to strengthen the math program. In the elementary, teachers that are more inclined towards math could teach math to more than one grade in exchange for one or more subjects in their classroom.

In conclusion, this study has shown that many of the initial issues that prompted this study have already been resolved and that JCS appears to have a healthy math program. The parental concern about students not knowing their math facts seems to have been resolved by the Mastering Math Facts program, which now appears to be one of the strengths of the elementary program. The elementary teachers are very satisfied with the ease of implementing their Saxon curriculum, and the review that it demands of students seems to have improved student retention. Since the Saxon curriculum was implemented no class scores have been below the national average. Regarding the ACT scores which were a concern to the administration, the scores are generally above the national average and have had a general trend upward. Of special note is last year's recent shift in scores out of the bottom two ACT ranges and the increase in percent of students in the higher brackets. Concerning the delay of teaching algebra until ninth grade, the students seem to do well on standardized tests even though they don't begin a

formal course in algebra until ninth grade. Students that enroll in JCS in ninth grade who have already had algebra generally find that it is a good review for them and it helps clarify many concepts that they did not fully understand if they took algebra in eighth grade. JCS students do have the opportunity to pick up an extra math class their junior year and that extra knowledge is helpful to them when they take the ACT test. They also have the opportunity of taking online math classes through other programs.

Therefore, the math program at JCS has much to offer students. As with any program, teachers and administrators should continue to examine and review the program each year to see where improvements can be made. Teachers need to continue to help students understand the concepts behind the procedural skills that are applied in solving problems. Furthermore, teachers need to continue to develop the math skills of all students so that they are equipped to the best of their ability to impact the world for Christ, not only in everyday life but also in areas that require in-depth math skills.

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APPENDIX A

Table A1

JCS Alignment With NCTM Curriculum Focal Points

Grade	Focal Point	Connecting Concepts taught in a later grade
Kinder-garten	***1. Number and Operations* and *Algebra:*** Developing understandings of addition and subtraction and strategies for basic addition facts and related subtraction facts ***2. Number and Operations:*** Developing an understanding of whole number relationships, including grouping in tens and ones ***3. Geometry:*** Composing and decomposing geometric shapes	
1	***1. Number and Operations* and *Algebra:*** Developing understandings of addition and subtraction and strategies for basic addition facts and related subtraction facts ***2. Number and Operations:*** Developing an understanding of whole number relationships, including grouping in tens and ones ***3. Geometry:*** Composing and decomposing geometric shapes	
2	***1. Number and Operations* and *Algebra:*** Developing an understanding of the base-ten numeration system and place-value concepts ***2. Number and Operations:*** Developing a quick recall of addition facts and related subtraction facts and fluency with multidigit addition and subtraction ***3. Geometry:*** Developing an understanding of linear measurement and facility in measuring lengths	The smaller the unit of measurement the more units needed to cover a length

Table A1 (cont.)

JCS Alignment with NCTM Curriculum Focal Points

Grade	Focal Point	Connecting Concepts taught in a later grade
3	***1. Numbers and operations and algebra*** Developing understandings of multiplication and division and strategies for basic multiplication facts and related division facts	Construct and analyze frequency tables and line plots and use them to solve problems
	2. Number and Operations: Developing an understanding of fractions and fraction equivalence	
	3. Geometry: Analyzing properties of two-dimensional shapes	Describe, and reason about decomposing, combining, and transforming polygons to make other polygons
4	***1. Numbers and operations and algebra*** Developing quick recall of multiplication facts and related division facts and fluency with whole number multiplication	
	2. Number and Operations: Developing an understanding of decimals, including the connections between fractions and decimals	Stem-and-leaf plots
	3. Geometry: Developing an understanding of area and determining the areas of two-dimensional shape	
5	***1. Numbers and operations and algebra*** Developing quick recall of multiplication facts and related division facts and fluency with whole number multiplication	
	2. Number and Operations: Developing an understanding of decimals, including the connections between fractions and decimals	
	3. Geometry: Developing an understanding of area and determining the areas of two-dimensional shapes	Finding surface area and volume of prisms

Table A1 (cont.)

JCS Alignment with NCTM Curriculum Focal Points

Grade	Focal Point	Connecting Concepts taught in a later grade
6	***1. Numbers and operations and algebra*** Developing an understanding of and fluency with multiplication and division of fractions and decimals	Distinguish multiplicative comparisons from additive comparisons
	2. *Number and Operations:* Connecting ratio and rate to multiplication and division	
	3. *Algebra:* Writing, interpreting, and using mathematical expressions and equations	Solve simple one-step equations by using number sense and properties of operation Construct and analyze tables and use equations to describe simple relationships shown in a table Illustrate properties of operations by showing that two expressions are equivalent Use sequences to develop formulas Find area and volume from lengths or find lengths from given volumes and areas

Table A1 (cont.)

JCS Alignment with NCTM Curriculum Focal Points

Grade	Focal Point	Connecting Concepts taught in a later grade
7	***1. Numbers and operations and Algebra and Geometry*** Developing an understanding of and applying proportionality, including similarity	Find percent of increase or decrease Use scale factors to solve problems of similarity Graph proportional relationships and identify the unit rate as the slope of the related line Distinguish between proportional and inversely proportional relationships
	2. *Measurement and Geometry and Algebra:* Developing an understanding of and using formulas to determine surface areas and volumes of three-dimensional shapes	Understand that the formula for the area of a circle is plausible by decomposing a circle into wedges and rearranging them into a parallelogram shape Understand that scale factors describe relationships between similar objects, the square of scale factors describes how areas are related, and the cube of scale factors describes how volumes are related
	3. *Number and Operations and Algebra:* Developing an understanding of operations on all rational numbers and solving linear equations	Use proportions to make estimates relating to population on the basis of a sample Apply percentages to make and interpret histograms and circle graphs
8	**1. *Algebra*:** Analyzing and representing linear functions and solving linear equations and systems of linear equations	
	2. *Geometry and Measurement:* Analyzing two- and three-dimensional space and figures by using distance and angle	
	3. *Data Analysis and Number and operations and Algebra:* Analyzing and summarizing data sets	Box-and-whisker plots

Table A2

JCS Alignment with Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
K	Counting and Cardinality	○ Know number name and the count sequence ○ Count to tell the number of objects ○ Compare numbers	100%	
	Operations and Algebraic Thinking	○ Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from	100%	
	Number and operations in BaseTen	○ Work with numbers 11 – 19 to gain foundations for place value	100%	
	Measure-ment and Data	○ Describe and compare measurable attributes ○ Classify objects and count the number of objects in categories	100%	
	Geometry	○ Identify and describe shapes ○ Analyze, compare, create, and compose shapes	100%	
1	Operations and Algebraic Thinking	○ Represent and solve problems involving addition and subtraction ○ Understand and apply properties of operations and the relationship between addition and subtraction ○ Add and subtract within 20 ○ Addition and subtraction equations		○ Add and subtract between 11 and 20 ○ Determine if equations involving addition or subtraction are true or false. For example, does 4 + 1 = 5 + 2?
	Number and Operations in BaseTen	○ Extend the counting sequence ○ Understand place value ○ Use place value and properties of operations to add and subtract	66%	○ Add within 100 ○ Given a two-digit number, mentally find 10 more or 10 less than the number
	Measure-ment and Data	○ Measure lengths indirectly and by iterating length units ○ Tell and write time ○ Represent and interpret data	100%	

Table A2 cont.

JCS Alignment with Michigan Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
2	Operations and Algebraic Thinking	○ Represent and solve problems involving addition and subtraction ○ Add and subtract within 20 ○ Work with equal groups of objects to gain foundations for multiplication	75%	Write an equation to express the total as a sum of equal addends
	Number and Operations in BaseTen	○ Understand place value ○ Use place value understanding and properties of operations to add and subtract	100%	
	Measure-ment and Data	○ Measure and estimate lengths in standard units ○ Addition and subtraction of length ○ Work with time and money ○ Represent and interpret data	90%	Show measurements of several objects on a line plot
	Geometry	○ Reason with shapes and their attributes	100%	
3	Operations and Algebraic Thinking	○ Represent and solve problems with multiplication and division ○ Understand properties of multiplication and the relationship between multiplication and division ○ Multiply and divide within 100 ○ Solve problems involving the four operations, and identify and explain patterns in arithmetic	78%	Solve two-step word problems using the four operations with equations and letters representing unknown quantities Identify arithmetic patterns and explain them using properties of operations
	Number and Operations in BaseTen	○ Use place value understanding and properties of operations to perform multi-digit arithmetic	100%	
	Number and operations (Fractions)	○ Develop understanding of fractions as numbers	100%	Express whole numbers as fractions
	Measure-ment and Data	○ Solve problems involving measurement and estimation of intervals of time, liquid volumes, and masses of objects ○ Represent and interpret data ○ Understand concepts of area and relate area to multiplication and addition ○ Geometric measurement: recognize perimeter as an attribute of plane figures and distinguish between linear and area measures	92%	Show data on a line plot with fractional increments Find areas of rectilinear figures by decomposing them into non-overlapping rectangles and adding the areas
	Geometry	○ Reason with shapes and their attributes	100%	

Table A2 cont.

JCS Alignment with Michigan Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
4	Operations and Algebraic Thinking	○ Use the four operations with whole numbers to solve problems ○ Gain familiarity with factors and multiples ○ Generate and analyze patterns	60%	Identify features not explicitly stated for a generated number pattern
	Number and Operations in Base Ten	○ Generalize place value understanding for multi-digit whole numbers ○ Use place value understanding and properties of operations to perform multi-digit arithmetic	100%	
	Number and operations--Fractions	○ Extend understanding of fraction equivalence and ordering ○ Build fractions from unit fractions by applying and extending previous understandings or operations on whole numbers ○ Understand decimal notation for fractions, and compare decimal fractions	58%	Add and subtract mixed numbers with like denominators Add fractions with respective denominators of 10 and 100 Multiply fractions
	Measure-ment and Data	○ Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit ○ Represent and interpret data ○ Understand concepts of angle and measure angles	38%	Solve problems involving addition and subtraction of fractions by using information presented in line plots Measure angles Solve addition and subtraction problems to find unknown angles on a diagram
5	Operations and Algebraic Thinking	○ Write and interpret numerical expressions ○ Analyze patterns and relationship	100%	
	Number and Operations in Base Ten	○ Understand place value system ○ Perform operations with multi-digit whole numbers and with decimals to hundredths	100%	Expanded form
	Number and operations--Fractions	○ Use equivalent fractions as a strategy to add and subtract fractions ○ Apply and extend previous understandings of multiplication and division to multiply and divide fractions	91%	Use visual fraction model to show the quotient of a whole number and a unit fraction Use the relationship between multiplication and division to explain such things like $4 \div 1/5 = 20$ because $20 \times 1/5 = 4$

Table A2 cont.

JCS Alignment with Michigan Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
5	Measure-ment and Data	○ Convert like measurement units within a given measurement system ○ Represent and interpret data ○ Geometric measurement: understand concepts of volume and relate volume to multiplication and to addition	83%	Volume of a right rectangular prism
	Geometry	○ Graph points on the coordinate plane to solve real-world and mathematical problems ○ Classify two-dimensional figures into categories based on their properties	100%	
6	Ratios and proportional Relationships	○ Understand ratio concepts and use ratio reasoning to solve problems	33%	Understand unit rate as a ratio Make tables of equivalent ratios, find missing values in a table, and plot values Find percents, solve problems involving finding the whole, given a part and percent Use ratio reasoning to convert measurement units
	The Number System	○ Apply and extend previous understandings of multiplication and division to divide fractions by fractions ○ Compute fluently with multi-digit numbers and find common factors and multiples ○ Apply and extend previous understandings of numbers to the system of rational numbers	46%	Understand signs of numbers in ordered pairs and locations in quadrants Plot ordered pairs Interpret statements of inequality as relative positions on a number line Explain statements of order for rational numbers in real-world contexts Understand absolute value as distance from zero Distinguish comparisons of absolute value from statements about order Solve problems by graphing points in all four quadrants and find distances between points with same first coordinate or same second coordinate

Table A2 cont.

JCS Alignment with Michigan Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
6	Expressions and Equations	○ Apply and extend previous understandings of arithmetic to algebraic expressions ○ Reason about and solve one-variable equations and inequalities ○ Represent and analyze quantitative relationships between dependent and independent variables	73%	Use formulas to solve problems and apply order of operation rules Write inequalities to represent a constraint or condition in a problem Use variables to represent quantities and analyze the relationship using graphs and tables
	Geometry	○ Solve real-world and mathematical problems involving area, surface area, and volume	0%	Find area of triangles, special quadrilaterals, and polygons Find volume of right rectangular prisms Draw polygons in the coordinate plane and use them to solve problems Represent three-dimensional figures using nets and find surface area of the nets
	Statistics and probability	○ Develop understanding of statistical variability ○ Summarize and describe distributions	25%	Describe the nature of the attributes of a distribution under investigation Relate the choice for measure of central tendency to the shape of the data distribution
7	Ratios and proportional Relationships	○ Analyze proportional relationships and use them to solve real-world and mathematical problems	50%	Decide if relationships are proportional by using tables or graphs in a coordinate plane Identify the constant of proportionality in tables, graphs, equations, and diagrams Explain what a point on the graph of a proportional relationship represents
	The Number System	○ Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers	100%	

Table A2 cont.

JCS Alignment with Michigan Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
7	Expressions and Equations	○ Use properties of operations to generate equivalent expressions ○ Solve real-life and mathematical problems using numerical and algebraic expressions and equations	40%	Apply properties of operations as strategies to add, subtract, factor, and expand linear expressions with rational coefficients Rewrite expressions in different forms to show how quantities are related Solve word problems leading to inequalities. Graph and interpret the inequality.
	Geometry	○ Draw, construct and describe geometrical figures and describe the relationships between them ○ Solve real-life and mathematical problems involving angle measure, area, surface area, and volume	67%	Solve problems involving scale drawings Describe the two-dimensional figures that result from slicing three-dimensional figures
	Statistics and probability	○ Use random sampling to draw inferences about a population ○ Draw informal comparative inferences about two populations ○ Investigate chance processes and develop, use, and evaluate probability models	27%	Generalizing about a population from a representative sample Generate multiple samples to gauge the variation in estimates or predictors Informally assess the degree of visual overlap of two distributions with similar variability Use measures of center and variability from sample to draw inferences about population Understand the probability of a chance event is a between zero and one Understand the probability of a compound event is the fraction of outcomes in the sample space Represent sample spaces for compound events using lists, tables and tree diagrams Use a simulation to generate frequencies for compound events

Table A2 cont.

JCS Alignment with Michigan Common Core State Standards

Grade	Domain	Overview of the cluster of standards	Concepts taught this grade	Concepts taught in a later grade
8	The Number System	○ Know that there are numbers that are not rational, and approximate them by rational numbers	100%	
	Expressions and Equations	○ Work with radicals and integer exponents ○ Understand the connections between proportional relationships, lines, and linear equations ○ Analyze and solve linear equations and pairs of simultaneous linear equations	91%	Use square root and cube root symbols to represent solutions and evaluate them
	Functions	○ Define, evaluate, and compare functions ○ Use functions to model relationships between quantities	60%	Understand a function is a rule that assigns exactly one output to each input Compare properties of two functions represented in a different way algebraically, graphically, or numerically
	Geometry	○ Understand congruence and similarity using physical models, transparencies, or geometry software ○ Understand and apply the Pythagorean Theorem ○ Solve real-world and mathematical problems involving volume of cylinders, cones, and spheres	36%	Verify experimentally the properties of rotation, reflection, and translation for lines and angles Given two congruent figures, describe a sequence that exhibits the congruence Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates
	Statistics and probability	○ Investigate patterns of association in bivariate data	75%	For scatter plots that suggest a linear association, informally find the line of best fit

Table A3

JCS Alignment with Michigan High School Common Core State Standards

Strand	Domain	Overview of the cluster of standards	Concepts taught	Concepts not taught
Number and Quantity	The Real Number System	○ Extend the properties of exponents to rational exponents ○ Use properties of rational and irrational numbers	100%	
	Quantities	○ Reason quantitatively and use units to solve problems	100%	
	The Complex Number System	○ Perform arithmetic operations with complex numbers ○ Represent complex numbers and their operations on the complex plane ○ Use complex numbers in polynomial identities and equations	100%	
	Vector and Matrix Quantities	○ Represent and model with vector quantities ○ Perform operations on vectors ○ Perform operations on matrices and use matrices in applications	100%	
Algebra	Seeing Structure in Expressions	○ Interpret the structure of expressions ○ Write expressions in equivalent forms to solve problems	100%	
	Arithmetic with Polynomials and Rational Expressions	○ Perform arithmetic operations on polynomials ○ Understand the relationship between zeros and factors of polynomials ○ Use polynomial identities to solve problems ○ Rewrite rational expressions	86%	Prove polynomial identities and use them to describe numerical relationships
	Creating Equations	○ Create equations that describe numbers or relationships	100%	
	Reasoning with Equations and Inequalities	○ Understand solving equations as a process of reasoning and explain the reasoning ○ Solve equations and inequalities in one variable ○ Solve systems of equations ○ Represent and solve equations and inequalities graphically	100%	
Functions	Interpreting Functions	○ Understand the concept of a function and use function notation ○ Interpret function that arise in applications in terms of the context ○ Analyze functions using different representations	100%	
	Building Functions	○ Build a function that models a relationship between two quantities ○ Build new functions from existing functions	100%	

Table A3 cont.

JCS Alignment with Michigan High School Common Core State Standards

Strand	Domain	Overview of the cluster of standards	Concepts taught	Concepts not taught
Functions	Linear, Quadratic, and Exponential Models	○ Construct and compare linear, quadratic, and exponential models and solve problems ○ Interpret expressions for functions in terms of the situation they model	86%	Prove that linear functions grow by equal differences over equal intervals and exponential functions grow by equal factors over equal intervals
	Trigono-metric Functions	○ Extend the domain of trigonometric functions using the unit circle ○ Model periodic phenomena with trigonometric function ○ Prove and apply trigonometric identities	100%	
Geometry	Congruence	○ Experiment with transformations in the plane ○ Understand congruence in terms of rigid motions ○ Prove geometric theorems ○ Make geometric constructions	100%	
	Similarity, Right Triangles, and Trigonometry	○ Understand similarity in terms of similarity transformations ○ Prove theorems involving similarity ○ Define trigonometric ratios and solve problems involving right triangles ○ Apply trigonometry to general triangles	92%	Verify a dilation takes a line not passing through the center of the dilation to a parallel line and leaves a line passing through the center unchanged
	Circles	○ Understand and apply theorems about circles ○ Find arc lengths and areas of sectors of circles	100%	
	Expressing Geometric Properties with Equations	○ Translate between the geometric description and the equation for a conic section ○ Use coordinates to prove simple geometric theorems algebraically	71%	Use coordinates to prove geometric theorems Find the point on a directed line segment between two given points that partitions the segment in a given ratio

Table A3 cont.

JCS Alignment with Michigan High School Common Core State Standards

Strand	Domain	Overview of the cluster of standards	Concepts taught	Concepts not taught
Geometry	Geometric Measurement and Dimensions	○ Explain volume formulas and use them to solve problems ○ Visualize relationships between two- dimensional and three-dimensional objects	100%	
	Modeling in Geometry	○ Apply geometric concepts in modeling	100%	
Probability and Statistics	Interpreting Categorical and Quantitative Data	○ Summarize, represent, and interpret data on a single count or measurement variable ○ Summarize, represent, and interpret data on two categorical and quantitative variables ○ Interpret linear models	73%	Use mean and standard deviation to fit a data set to a normal distribu-tion and estimate population percentages Distinguish between correlation and causation
	Making Inferences and Justifying Conclusions	○ Understand and evaluate random processes underlying statistical experiments ○ Make inferences and justify conclusions from sample surveys, experiments and observational studies	33%	Recognize the purposes and differences in sample surveys and experiments Estimate a population mean; develop a margin of error Compare two treatments; use simulations to see significance in parameters Evaluate reports based on data
	Conditional Probability and the Rules of Probability	○ Understand independence and conditional probability and use them to interpret data ○ Use the rules of probability to compute probabilities of compound events in a uniform probability model	78%	Explain the concepts of conditional probability and independence Find conditional probability of A given B, as the fraction of B's outcomes that also belong to A, and interpret in terms of the model

Table A3 cont.

JCS Alignment with Michigan High School Common Core State Standards

Strand	Domain	Overview of the cluster of standards	Concepts taught	Concepts not taught
Probability and Statistics	Using probability to Make Decisions	○ Calculate expected values and use them to solve problems ○ Use probability to evaluate outcomes of decisions	0%	Define a variable by assigning a numerical value to each event; graph the distribution Calculate an expected end; interpret it as the mean of the probability distribution

APPENDIX B

JCS Class Average Math Scores Compared to the National Average Math Scores

	K	1	2	3	4	5	6	7	8	9
Class of 2012						656	678	699	707	729
Points above national average						17	23	36	32	44
Change from previous year in relative position to national average							+4	+13	-4	+12
Class of 2013						655	666	703	707	722
Points above national average						16	11	40	32	37
Change from previous year in relative position to national average							-5	29	-8	5
Class of 2014					647	655	671	699	708	726
Points above national average					29	16	16	36	33	41
Change from previous year in relative position to national average						-13	0	20	-3	8
Class of 2015				588	608	632	652	668	676	
Points above national average				-18	-10	-7	-3	5	1	
Change from previous year in relative position to national average					8	3	4	8	-4	
Class of 2016			579	620	643	655	659	673		
Points above national average			3	14	25	16	4	10		
Change from previous year in relative position to national average				11	11	-9	-12	6		
Class of 2017		551	597	602	651	665	660			
Points above national average		21	21	-5	33	26	5			
Change from previous year in relative position to national average			0	-26	38	-7	-21			

	K	1	2	3	4	5	6	7	8	9
Class of 2018		544	569	631	653	672				
Points above national average		14	-7	25	35	33				
Change from previous year in relative position to national average			-21	32	10	-2				
Class of 2019		595	615	656	666					
Points above national average		65	39	50	48					
Change from previous year in relative position to national average			-26	11	-2					
Class of 2020		558	604	633						
Points above national average		28	28	27						
Change from previous year in relative position to national average			0	-1						
Class of 2021	530	561	600							
Points above national average	38	31	24							
Change from previous year in relative position to national average		-7	-7							
Class of 2022	531	545								
Points above national average	39	15								
Change from previous year in relative position to national average		-24								

APPENDIX C

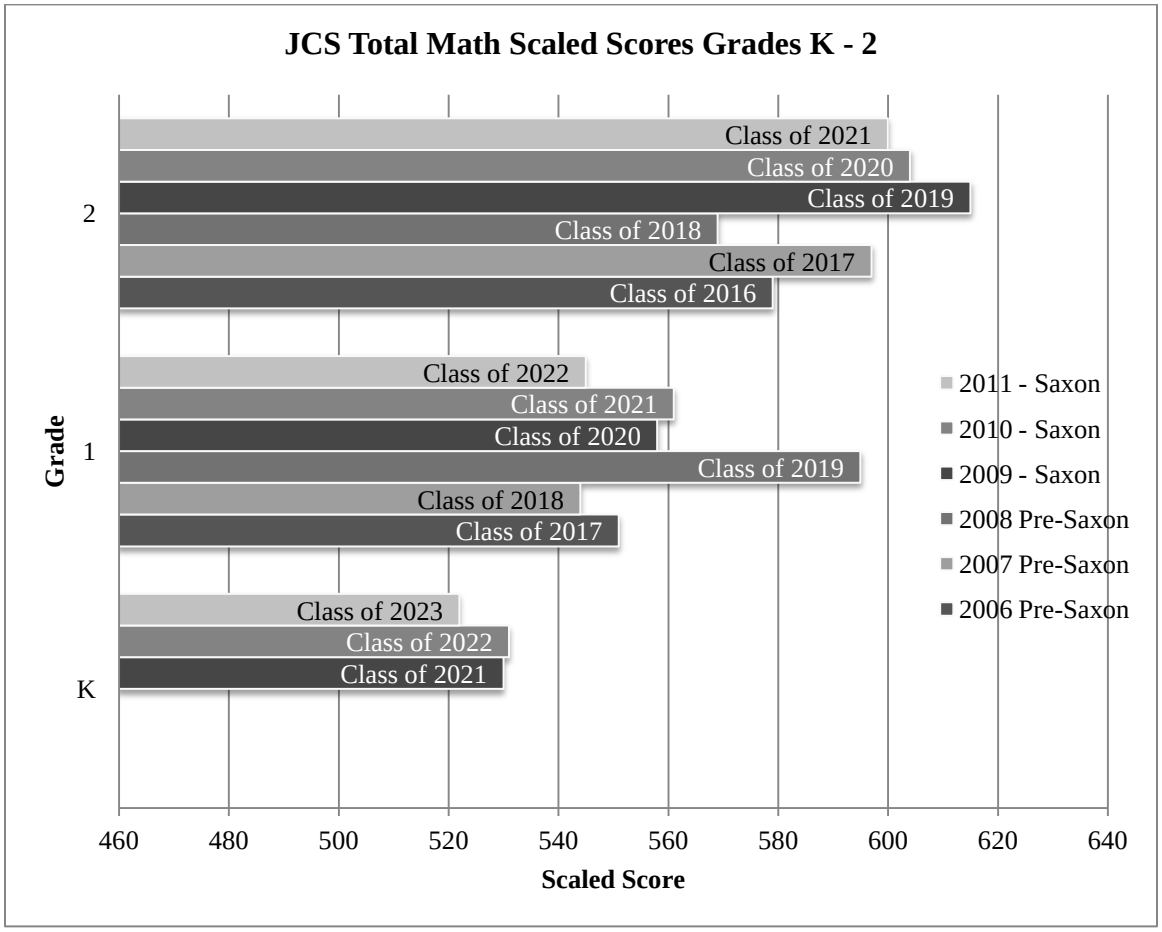

Figure C1. JCS total math scaled scores grades K – 2. Kindergarten Class used ABeka curriculum each year.

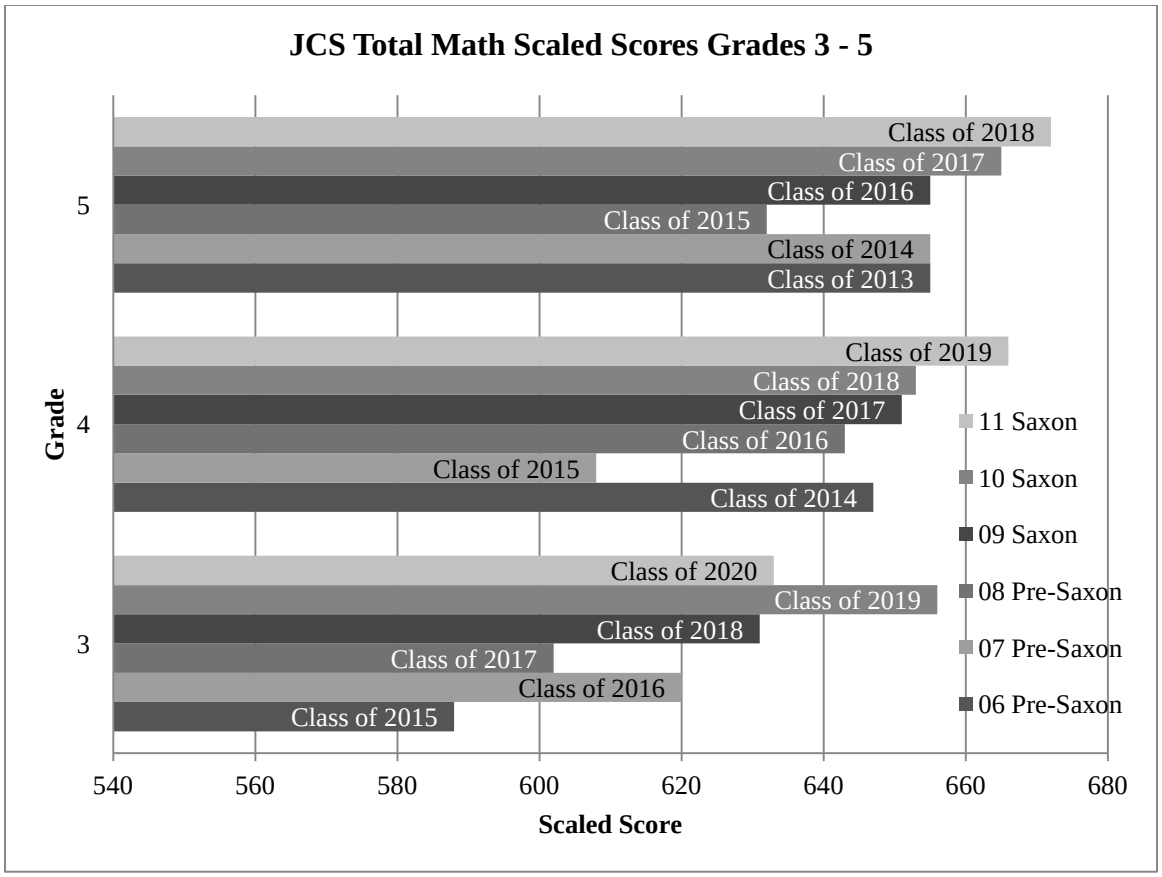

Figure C2. JCS total math scaled scores grades 3 – 5.

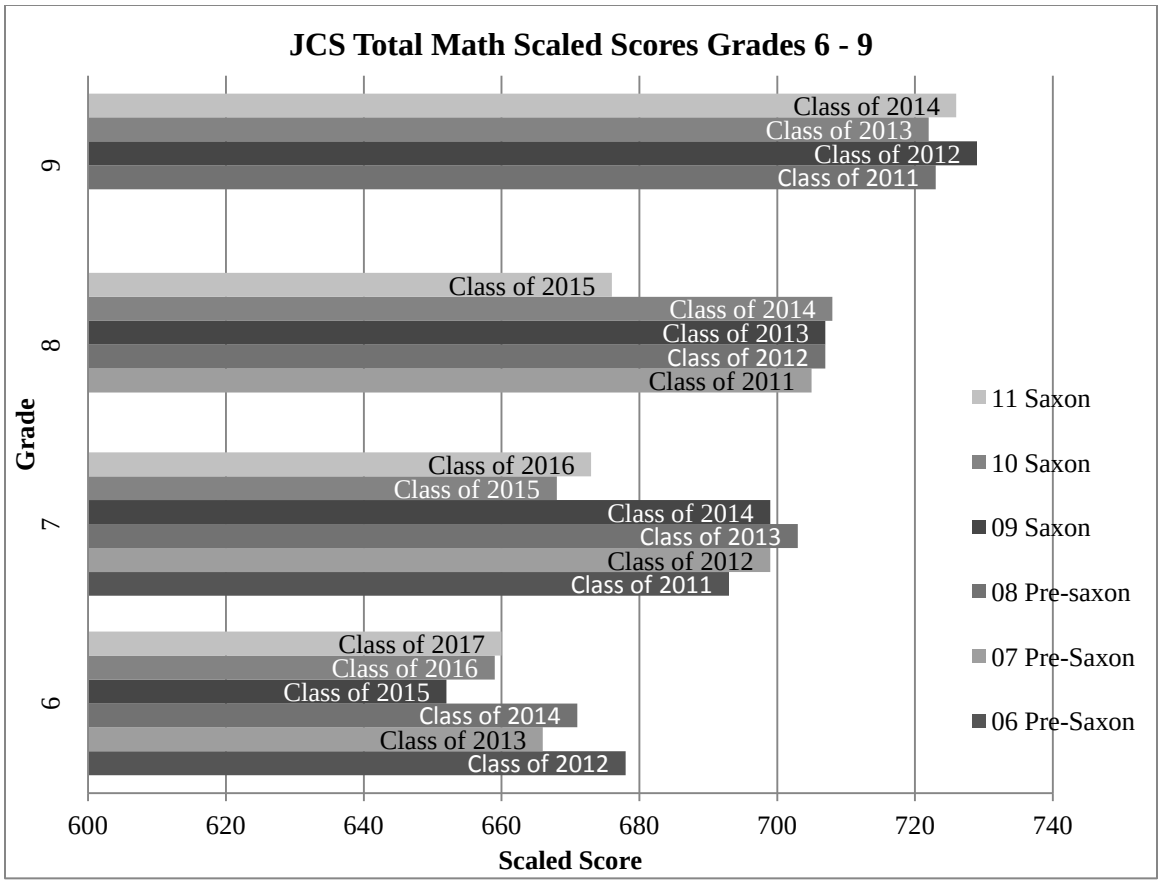

Figure C3. JCS total math scaled scores grades 6 – 9.