

MIDDLE-SCHOOL MATHEMATICS
CURRICULUM REFORM IN JAPAN AND GEORGIA

by

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(UNDER THE DIRECTION OF JEREMY KILPATRICK)

ABSTRACT

Japanese curriculum changes between the 1989 and 1998 Guidelines for Instruction and Learning (Junior High School) and the 2004-2005 adaptation of the 1989 Guidelines for Mathematics by the Georgia Board of Education as a replacement for its middle school Quality Core Curriculum Mathematics Standards are analyzed. Side-by-side comparisons of the pre- and post-reform Japanese curricula are listed, as well as a listing of changes made by Georgia in its adoption. This study finds that Japanese curriculum reform was for relaxed standards, whereas the Japanese standards as interpreted and adopted by Georgia were the more demanding standards abandoned by the Japanese Ministry of Education.

INDEX WORDS: Mathematics Education, Curriculum, International,
Japan, Georgia, Reform, Middle School, Quality Core Curriculum

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1 Background and Purpose

In 2005, curriculum reform in Georgia and in Japan was moving in a similar direction for quite different reasons. In Japan, the Ministry of Education found itself under attack by educators, parents, and scholars for having gone too far in trying to escape the reputation of having pressure cooker-like schools that destroyed student creativity and freedom by putting too much emphasis on an overly academic curriculum. Perhaps guided by student-centered educational reform movements in the West, the Ministry had only 2 years previously completed a gradual reform of its curriculum that had begun decades before. By 2005, however, the Ministry was starting to undo many of these changes in response to falling test scores and apparent declines in student motivation.

Georgia, on the other hand, was in the middle of a massive curriculum overhaul in an effort to improve chronic problems with mathematics in its schools. Its ranking for 2 years in a row as the state with the lowest Scholastic Aptitude Test scores (followed by a year in the next-to-last position) (College Board, 2002, 2003, 2004) attested to the need for reform of some sort, and a 2001 curriculum review by Phi Delta Kappa had pointed towards curriculum improvement as a way that performance might be improved (GDE, 2005). The Georgia Board of Education had decided in 2004 to replace its previous curriculum guidelines—the Quality Core Curriculum (QCC)—with a newly developed set of standards called the Georgia Performance Standards (GPS). To replace the mathematics QCCs, the Georgia Board of Education chose to adapt the 1989 Japanese mathematics curriculum for use in the GPS.

A Brief History of Mathematics Curriculum Development in Japan

The standard for the public school mathematics curriculum in Japan is the *Gakushuu Shidou Youryou* [Guidelines for Instruction and Learning]. Three volumes are issued, one each for primary school (Grades 1–6), middle school (Grades 7–9), and high school (Grades 10–12). These guidelines lay out the number of classroom hours that students are expected to spend on each subject (such as mathematics) throughout the year, and contain a rough outline of the goals and content of each subject. In addition, there is a set of commentaries on the guidelines and a companion guide for each of the three curriculum books containing detailed notes about how the curriculum should and should not be handled for each subject.

The first set of guidelines was created immediately after World War II but was not published by the government as an official curriculum guide until 1958 (Japan Ministry of Education, Culture, Sports, Science, and Culture [Japan MEXT], 2000). The first major revisions of the mathematics curriculum took place in 1968–1970 with the introduction of ideas from group theory and with other changes meant to modernize the curriculum and bring it in line with then current mathematical thinking.

The current version of the Japanese standards has been undergoing revision since 1977, the year in which the Japanese Central Council for Education first introduced the concept of *yutori kyouiku* [relaxed education]. *Yutori kyouiku* was a response to a growing concern that too much pressure was being placed on children for high academic performance, which was seen as a cause of increasingly common incidents of violence and bullying in schools, dropouts, and other social problems. The new set of standards was put into effect in 1980, and additional revision of the standards was done in 1989

(and implemented in 1993) under the banner of *atarashii gakuryoku-kan* [a new concept of academic ability] (cf. Appendix A).

The scope of *yutori kyouiku* was greatly expanded with the most recent overhaul of Japan’s curriculum, which was proposed in 1998 and implemented over the years 1999 to 2002 (cf. Appendices B and C). The highlights of this revision were the introduction of a 5-day school week (Japanese students had previously attended school for half days on Saturdays, though Saturday attendance was being gradually phased out under previous revisions), accompanied by an approximate 30% reduction in curriculum content and 70 fewer hours of classroom time per school year (Gakken Kyoshitsu, 2004). Mathematics class time was reduced from 175 hours per school year to 150 hours. Another major change was the introduction of “integrated studies” periods, which were envisioned as a chance for “experience-based and problem solving-focused learning” that would “increase students’ desire to learn” (Japan MEXT, 2000). The new curriculum also increased elective course opportunities and promised a focus on “teaching to the individual child.” See Table 1 for a timeline of curriculum revisions in Japan.

Table 1. A Timeline of Japan's Curriculum Revisions

Year	Event
1958	The Guidelines for Learning and Instruction become the legal curriculum plan for all public schools in Japan
1977	Major revision of the guidelines introduces the phrase <i>yutori kyouiku</i>
1980	The 1977 guidelines are implemented in schools

- 1989 The guidelines are again revised, with a decrease in the amount of content studied and a reduction in class time
- 1992 Every second Saturday of each month becomes a school holiday
- 1993 The 1989 revision to the guidelines goes into effect
- 1995 All Saturdays become school holidays; science and civics classes are removed from 1st and 2nd grades and replaced with “living” classes
- 1998 Guidelines are again revised, with further reduction in curriculum content and class time, and creation of “integrated studies” classes; all Saturdays become holidays
- 2002 Implementation of the 1998 revision completed
-

A Brief History of Mathematics Curriculum Development in Georgia

In 1986, the Georgia legislature passed the Quality Basic Education (QBE) Act, which mandated Georgia’s Quality Core Curriculum (QCC), a standard curriculum guide for all school systems in the state (Georgia Department of Education [GDE], 1998). This guide provided a common framework for systems to base curriculum development on, and systems were encouraged to add to the QCC as they saw fit. The QBE Act required review and revision of the QCC every 4 years, but because of budget restraints the first revision was not performed until 1995–1996, and not implemented until 1998. The 1995–1996 revision reflected opinions and suggestions from Georgia teachers, over 93% of whom said in a poll of 8,000 teachers that the QCC should be revised, not replaced (GDE, 1999).

In 2001, the Georgia State Board of Education requested a review of the QCC by Phi Delta Kappa (GBE, 2005). That audit appraised the QCC as too broad and as lacking in both rigor and depth. It said that goals for each subject needed to be made clearer. The result was a decision in 2003 to totally rewrite Georgia's curriculum, now called the Georgia Performance Standards (GPS). The QCC for mathematics was replaced with standards based on an English translation of the 1989 Japanese Guidelines for Learning and Instruction, making it "closely aligned with the Japanese standards" (GDE, 2004a). Like the 1989 Japanese standards, the new mathematics GPS followed the major "strands" of numbers and operations, measurement, geometry, and data analysis. High schools were to do away with the standard division of mathematics into courses such as Algebra I, Geometry, and Algebra II, and instead to adopt the Japanese model of including algebra, geometry, and other content strands in each of the courses.

The proposed new standards were made available during January of 2004 for public comment. The standards for grades K-8 were approved in July 2004 and posted in August 2004. For a complete timeline of the creation of the GPS see http://www.georgiastandards.org/documents/gps_implementation.pdf.

2 School Mathematics in 2004 and 2005

The Results of Japan's Yutori Kyouiku Experiment

The results of Japan's most recent curriculum revision were, by all accounts, a disaster. The reduced-length school week alone would have been enough to provoke controversy in a less conservative country, but the general sense of unease surrounding such huge changes was spurred on by misunderstandings concerning what was to be introduced. For example, for a time the public was outraged over a rumor that the new standards defined pi as "about 3."¹ In 1999, the release of the book *Bunsuu ga Dekinai Daigakusei* [College Students Who Can't Do Fractions] (Okabe, Nishimura & Seto, 1999) resulted in *gakuryoku teika* [decreasing academic ability] becoming a catch phrase, and books with titles such as *How Yutori Kyouiku Will Destroy Japan* (Sakurai & Miyakawa, 2005) and *How To Save Our Children From Yutori Kyouiku* (Wada, 2002) began to appear on bookstore shelves. Concerned parents bombarded the ministry of education with complaints, and one prominent scholar after another condemned the new educational paradigm.

The ministry of education at first denied that Japan's students were slipping academically, but reports showing that they were using their newfound free time to play video games and watch television had an effect on the ministry. In 2002, the year that

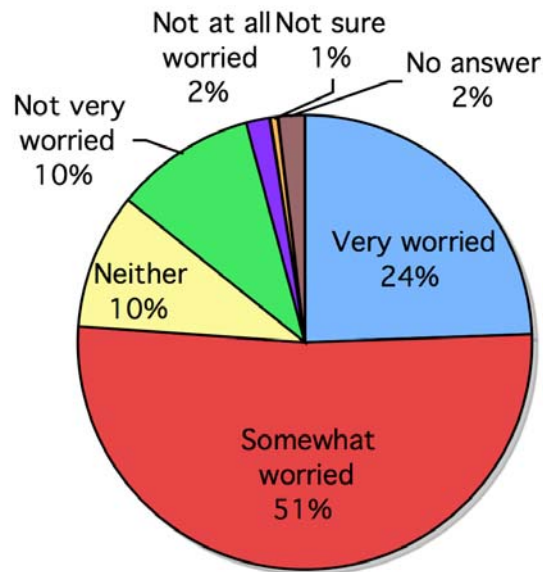
¹ In actuality, the new standards stated that "about 3" should be used when quickly estimating circle circumferences and areas.

yutori kyouiku went into full effect, the phrase *tashika na gakuryoku* [sound academic ability] became the Ministry's new slogan, and some prefectural school districts began reintroducing Saturdays classes to help slower students catch up (More and more, 2003).

Although the guidelines had always been held as the standard for mathematics education throughout the country, in response to complaints about the weakening of the curriculum, in 2002 the ministry of education modified the status of the guidelines as "a minimum standard" for curriculum development. The textbooks that had been approved by the ministry for use in schools, however, adhered closely to the guidelines, and therefore it was widely acknowledged that the guidelines actually represented a de facto standard. Instead, the private *juku* [cram schools] took up the responsibility for teaching the material that had been cut, because that material would still appear on college entrance examinations.

According to a poll performed by the *Asahi Elementary School Newspaper*, 58.7% of teachers claimed to be "worried" about falling academic ability because of the cuts in curriculum content and classroom time, and only 15% responded that they were "not at all worried" (Gakken Kyoshitsu, 2004). In a 2003 Japan Parents Teachers Association poll of 6000 parents and guardians of elementary and middle school students, approximately 75% said they were "worried" or "extremely worried" about falling academic ability (see Figure 1).

Figure 1. 2003 Japan Parents and Teachers Association Poll: Responses to "Are you worried about falling academic ability?" Data from Japan PTA National Council, 2003, http://www.nippon-pta.or.jp/kouhou299/kouhou_09.html



Starting in 2005, textbooks approved by the Japan Ministry of Education were allowed to contain the material that had been cut from the previous standards. In addition, textbooks were to be allowed to contain material that was officially slated for introduction in the following grade.

Some private schools had already started turning back the clock. For example, after only one year of trying the 5-day school week, private schools in Tokyo's Toshima and Minato Wards, Higashi-Murayama City, Tama City, and Akiruno City had preemptively returned to a 6-day school week because of complaints from parents that students were not using weekend free time wisely (More and more, 2003).

Georgia

The Georgia Board of Education (GBE) approved Georgia's new GPS mathematics standards for Grades K-8 in July 2004 and for Grades 9-12 in May 2005 (see Appendix D for a copy of the GPS for mathematics for Grades 6-8, as of May 2005). The GPS for Grades 6, 7, and 8 were scheduled for implementation over the 2005–2006, 2006–2007, and 2007–2008 school years, respectively.

Georgia uses a seven-year cycle for new textbook purchases, and mathematics textbooks were next scheduled for review in 2006 and adoption in 2007. Thus, GPS implementation began without new textbooks, and without textbook recommendations. The GBE stated that current middle school mathematics texts would need to be supplemented (GDE, 2005), but as of the summer of 2005 no lessons had been provided for teachers to use in the 2005–2006 school year.

A complete revision of the curriculum for all grades and all subjects meant that all teachers would be teaching at least some material that was new to them. The state had been developing teacher training materials and provided the training for one person from each district, but the delivery of this training to other teachers was the responsibility of the districts.

On many occasions, the GBE said that the new standards were “a living document” and were open to change. Significant changes had been made to the mathematics curriculum since their initial approval, and modifications would almost certainly continue for some time after implementation.

The situation in Georgia provides an interesting contrast to how curriculum reform has been performed in Japan. The Japan Ministry of Education has never performed a

total revision of its curriculum since its initial creation just after WWII. The *yutori kyouiku* changes are generally regarded as a fundamental shift in curriculum policy, so large as to create volumes of analysis and debate in the media and among scholars, and yet the scope of changes is arguably smaller than that represented by Georgia's wholesale curriculum revision in 2004. Nonetheless, the most recent changes in mathematics curriculum in Japan were decided upon and implemented gradually over the course of a decade, and the *yutori kyouiku* movement itself had been taking place for close to thirty years.

3 Comparisons Between the Curricula

The 1989 and 1998 Japanese Curricula

The ministry of education gave the following as its guiding principles for the 1998 revision of the Guidelines for Learning and Instruction:

Every school will develop, within a 5-day school week schedule, a distinctive education free of pressure that not only gives students a firm grasp on the basic and fundamental content provided by the Guidelines for Learning and Instruction, but also fosters forces for life such as a desire to learn and think for oneself.

1. The development of a rich humanity and sociability, and self-identity as a Japanese person living in an international society.
2. Conversion from an education that fills students with knowledge to one that develops a desire to learn and think for oneself.
3. To develop an education free from pressure, and an enriched education that provides both a firm grasp of fundamentals and individuality.
4. Creativity to develop a distinctive education and distinctive schools. (Japan MEXT 2005b, my translation)

An important thing to keep in mind when considering curriculum changes in their social context is the prevalence of *juku*, attended by over 27% of 10-year-olds and 47% of 13-year-olds² in Japan (Japan MEXT, 2004). An unspoken assumption made by the

² The percentage of 13-year-olds attending *juku* was much higher than for 12- or 14-year-olds because of increased numbers of students preparing for high school entrance

ministry of education when removing and simplifying the mathematics curriculum content is that these topics would not necessarily be “taken away” from students. Instead, the learning of these topics would take place solely within the *juku* by academically oriented students, and these topics would remain actively taught for as long as they appeared on high school and college entrance exams. It was easy, therefore, to completely move a content strand such as statistics and data analysis from junior high school to senior high school because the strand would in effect still exist in the *juku* for those students who needed it. The mathematics and science curriculum was to be reduced so that the content could be taught in approximately 80% of the time that was previously required, beginning with the removal or delay of content that was considered too advanced for students who would not be studying for entrance exams, content such as statistics, solid geometry, and geometric symmetry. The number of elective courses was increased in high schools, and to promote “distinctive education and distinctive schools” class time for integrated studies courses was added. For these courses, schools would develop their own curriculum to incorporate lessons from across multiple subjects.

In the new mathematics curriculum, the first major change was the removal of all statistics and data analysis content from the junior high schools, presumably on the grounds that statistics was one of the topics that was too complex for some students.

Less major yet still significant changes included:

exams. There is another spike in *juku* attendance at ages 17-18, when students begin preparing for college entrance exams.

- Redevelopment of pacing so that some topics (line and point symmetry, inverse proportions, etc.) were covered one year later than before
- Narrowing of focus in some topics (e.g., replacing multiple proportional measures by speed only in Grade 6)
- Simplification of the introduction of many topics (e.g., use of fraction reciprocals in rational number arithmetic)
- Removal of some topics (e.g., geometric translations and rotation)
- Introduction of some review of previously covered material (e.g., addition and subtraction of fractions in 6th grade)

Appendix C shows a detailed comparison of the 1989 and 1998 junior high school mathematics curricula.

The 1989 Japanese and 2004 Georgia Curricula

The newly developed Georgia mathematics curriculum, the Georgia Performance Standards (GPS) for Mathematics, is intended to be “closely aligned” with the Japanese Guidelines for Instruction and Learning. A translation of the 1989 Japanese standards was the primary document used in the creation of Georgia’s new standards, but close examination shows that some very large differences have appeared in the course of writing the GPS.

In general, the GPS present a much more demanding course of study than the Japanese guidelines do in that very little from the Japanese guidelines is left out, yet much has been added. This expansion is especially true in the 8th-grade curriculum, where the GPS looks like the Japanese guidelines, together with the addition of most of the algebra topics from the old QCC standards. One of the reasons given for the creation of the GPS was a need to make the Georgia curriculum “less than a mile wide” and “more than a half an inch deep” (GDE, 2005, p. 2). Although it is true that the new standards seem to be much more streamlined than the old ones, they are still quite bulky when compared with the old Japanese standards (recall that they subsequently underwent an approximate 30% reduction in content under the revision proposed in 1998).

In a May 13, 2004 presentation, the Georgia standards were presented as a move from a spiral to a ladder curriculum, which was said to be “extremely important—especially in math and science” (GDE, 2004b, p. 14). The ladder metaphor meant that there would be little or no time devoted to review or re-teaching of previously learned material and that teaching would be done on the assumption that all previous material

had been mastered. Meanwhile, in *Main Points of the New Guidelines for Learning and Instruction* (Japan MEXT, 2005b) the Ministry of Education listed as one of the specific improvements for elementary schools that “reading, writing, arithmetic, and other basic and fundamental content that is necessary in daily life shall be repeatedly taught so that students attain proficiency” (my translation). It seems that whereas Georgia was moving from a spiral to a ladder curriculum in imitation of the Japanese, the Japanese themselves had moved from a ladder to a spiral curriculum.

Another significant difference between the GPS and the Japanese guidelines is the naming of the strands of the curriculum. Whereas Georgia did away with independent courses in algebra and geometry, strands named algebra and geometry running through the curriculum were to be taught in parallel. The Japanese guidelines, in contrast, termed these strands “quantitative relationships” and “figures,” respectively. In fact, the Japanese words for algebra and geometry as branches of mathematics (*daisuu* and *kikagaku*, respectively) appeared nowhere in the Japanese guidelines. Perhaps avoiding the use of the names of traditional branches of mathematics made it easier for the Japanese guidelines to limit the topics covered without creating the impression that a subject had been given short shrift. For example, the GPS added the study of prime factorization and the Fundamental Theorem of Arithmetic to the 7th grade algebra strand, perhaps because these were considered topics in algebra that were too important to omit. Their absence from a course in “algebra” would make the course seem incomplete. On the other hand, the Japanese guidelines, which named this strand “quantitative relationships,” did not feel incomplete by the omission of important topics in algebra.

Regardless of whether or not the naming of these strands created preconceptions in the minds of the curriculum developers when they decided what to include, the designers of the GPS also showed a desire to cover topics more thoroughly than the Japanese guidelines by the longer vocabulary lists found in the GPS. For example, while the 1989 Japanese guidelines listed only 17 terms and symbols for introduction in the 7th grade (Japan MEXT, 1989b), the GPS for 7th grade mathematics listed 55 terms and symbols to be taught in relation to the geometry and algebra teaching strands (GDE, 2004a). When the terms from the added data analysis and probability strand were included, the total number of new terms and symbols reached 66.

The Japanese guidelines also tended to be more open-ended, and the GPS, more detailed and specific. This contrast is visible both in the main body of the standards and in supplementary notes and information. Although comments and clarifications in a separate section of the Japanese guidelines (included in brackets after the appropriate section in the translations provided in appendices A and B) tend to be warnings not to delve too deeply into the subject at hand, remarks added to the GPS tend to remind educators not to forget certain examples or methods. In addition, in May 2005 the GPS for Grade 6 were updated to include specific tasks that students would work through and that illustrated specific topics set forth by the GPS. An example is a simulation of preparing for a school science fair, a task comprising of seven subtasks, each in turn requiring use of various topics from the curriculum. For example, students were asked to fairly allocate available floor space based on the number of science fair students that would come from each school.

The GPS document appears to be a complete package of mathematics instruction, whereas the Japanese guidelines are more like a framework on which a school was to

develop its mathematics curriculum. This contrast reflects the environments in which these curricula were being used. In the United States the No Child Left Behind Act (2001) had set the focus of education at insuring that all students are able to receive a minimum level of instructional quality, and curriculum planners therefore must have felt that they needed to specify all details of what is to be taught for fear that anything left out would not be covered. Japan, on the other hand, had a long history of ability tracking by school, especially at the middle school and high school level. "High level" schools, therefore, were able to build a more challenging school-wide curriculum than schools that attracted lower-ability students, though both schools used the same guidelines as the basis for curriculum development.

Also important in allowing the Japanese guidelines to be much more vague than the GPS was the existence of commentaries on the guidelines. In addition to the Guidelines for Instruction and Learning, the Japan Ministry of Education also publishes Commentaries to the Guidelines for each subject. Whereas the guidelines have a very specific official role in that textbooks that are to be approved by the Ministry must address all topics listed in the guidelines, the commentaries are detailed statements concerning each item in the guidelines, explaining the rationale for including that topic, giving suggestions as to how it might be presented, and providing clarifications as to the depth to which the Ministry expects the presentation of the topic to be. The commentaries are quite rich and detailed. For example, whereas the 1998 guidelines for middle school mathematics are only 8 pages, the commentaries on those pages are approximately 175 pages long (Japan MEXT, 2003a, 2003b).

4 Potential Problems With Georgia's New Standards

A program of study for any subject does not exist in isolation. Many external factors profoundly affect its success or failure, including student preparedness, societal expectations of student performance, availability of appropriate texts, quality of instructors, and so on. These factors make it very difficult to pluck a set of standards as if fruit from a tree and successfully integrate them into a pre-existing educational environment. This integration is especially difficult when the standards in question come from another culture, and doubly so when the originating and adopting cultures are as different as the cultures of Georgia and Japan are.

In the case of Georgia's adoption of the Japanese standards, a significant oversight was Georgia's failure to obtain translations of not only the Guidelines for Instruction and Learning, but also the Ministry of Education's Commentaries on the Guidelines. As mentioned before, the guidelines are much shorter than the commentaries, which explain how the Ministry of Education thought that the framework should be fleshed out. Because Japan's curriculum was largely evolutionary rather than revolutionary since the end of World War II, the commentaries contain considerable accumulated wisdom on teaching according to the guidelines. Ignoring them entirely can only be detrimental to any attempted adoption of Japan's standards. Indeed, Georgia would have been better served had only translations of the commentaries been available, as the commentaries also contain the guidelines in their entirety.

In place of an equivalent to the commentaries, the GPS document contained text prescribing at each grade level that manipulatives and technology are to be used, that topics are to be presented in multiple fashions (concrete/pictorial, verbal/written, etc.),

and that subject-related books are to be read as part of a curriculum-wide effort to improve literacy. The National Council of Teachers of Mathematics process standards (National Council of Teachers of Mathematics, 2000) are also appended to the Japanese guidelines almost as an afterthought. There is no specific guidance, however, as to the details of how any of the above should be specifically implemented, greatly increasing the chances that these requirements will be applied inappropriately or even ignored altogether. Providing such guidance is exactly the role of the commentaries in the Japanese curriculum. If Georgia decides to stick with the Japanese model then the commentaries should be translated and evaluated. If future revisions of the GPS take the standards further away from the Japanese model, then a document similar to the Japanese commentaries should be created for use in Georgia.

The success of a mathematics curriculum for any state or country is of course also highly dependent on the availability of textbooks that support the structure and pacing of the curriculum. Availability of appropriate textbooks is not a problem in Japan, where a national curriculum ensures that textbook publishers have a clearly defined goal when creating texts—any text that follows the guidelines can be used in any school in any prefecture. The situation in Georgia is quite different. Mathematics textbooks in the United States are generally not written in a manner that supports simultaneous teaching of algebra, geometry, and statistics strands, and Georgia does not have the buying clout of Texas or California that might result in rapid adoption of the new curriculum by textbook publishers. In its executive summary of the GPS for mathematics, the GBE states that “most current elementary and middle school mathematics textbooks will need to be supplemented if the new standards are to be met,” and that “the biggest changes in mathematics textbooks will need to be at the high school level” (GDE, 2005),

but as of the year before the GPS were to be put into effect, the required supplementary materials were not provided, and replacement textbooks had not been suggested for any grade level.

The question as to whether Japan's curriculum is too difficult for rapid adoption in Georgia is also a valid one. On most measures of mathematical proficiency Georgia students perform below the national average, in a nation that is poorly ranked among industrialized nations worldwide. For example, the 2003 Trends in International Mathematics and Science Study (TIMSS) ranked the mathematics performance of 4th grade students in the United States at 12th among participating countries, and 8th grade performance was ranked 15th (National Center for Education Statistics [NCES], 2003a). Meanwhile 2003 National Assessment of Educational Progress data ranked Georgia 37th and 42nd in the United States for the same grades, respectively (NCES, 2003b). Yet the standards that Georgia is trying to adopt are not only from a country that is one of the highest-ranked in performance the world, but also standards that that country decided were too difficult for its own students and subsequently drastically simplified. Not only are Japan's standards difficult to begin with, but also as the comparison in appendix E shows, Georgia has added a significant amount of additional material to them.

An advanced curriculum also demands highly skilled teachers, and Georgia will likely have problems meeting this demand. Every year mathematics is listed as a critical teacher shortage field in Georgia, as it is in most of the rest of the country. The situation in Japan, however, where teaching is a job held in very high esteem, is quite different. In Metropolitan Tokyo, for example, for the 2005 school year there were 636 applications for 120 available public middle school mathematics teaching positions (Tokyo

Metropolitan Government Board of Education, 2004). Because of the popularity of teaching as a well-paid, respected job with good benefits, the profession has a very low turnover rate, and most hiring is done only to replace retiring teachers. This condition means that the average teacher has many years of experience and much familiarity with the Guidelines. Changes to the guidelines are also small ones and implemented gradually. Even the *yutori kyouiku* changes were made over a period of many years, and most of the changes were removal of topics and not replacement of what was taught. Georgia's curriculum change, in contrast, is a complete rewriting of the previous standards, meaning that every teacher in the state will be teaching a completely new curriculum for the first time. It would be surprising if the state were successful in providing teacher training sufficient to prepare teachers for such massive change.

That mathematics education in Georgia (as in the rest of the United States) needs to be improved is not in question. What is questionable, however, is whether a complete replacement of the QCC standards was the best way to do so. Although the 2001 Phi Delta Kappa review no doubt revealed some significant shortcomings of the QCC standards, that did not mean that those standards were beyond repair. It is also not clear that the new standards represent a significant improvement over the QCCs. For example the new standards received a B ranking by the Thomas B. Fordham Institute in their review of state mathematics standards (Klein, 2005), but that ranking is the same grade that the QCC standards had received.

The observation above leads to many questions: Why was the decision made to adopt an alien set of standards rather than polish the existing good standards to excellent quality? And given that it was decided that the previous standards could not be fixed, why not adopt the standards of, for example, Singapore, which not only is ranked higher

than Japan in international mathematics achievement, but also has standards and textbooks published in English? Why not adopt or at least use as a developmental base the A-ranked standards of California or Massachusetts, which already have curriculum-aligned published textbooks? Or the curriculum developed by the NCTM? Why is it necessary to implement a totally new curriculum in such a short time? Would it not have been better to implement the standards in a year-by-year schedule, or at a minimum starting with lower grades and working up, so that students in upper grades will not need to study content that the previous QCC standards did not prepare them for?

The biggest question of all, perhaps, is whether the curriculum is really the problem that most needs to be addressed in order to improve mathematics education in Georgia. In a presentation introducing the GPS given on May 13, 2004, Georgia State Superintendent of Schools Kathy Cox stated, "The TIMSS study reveals that students outside the United States don't perform better due to cultural reasons; achievement is different because of what is taught" (GDE, 2004b). This is indeed the attitude towards curriculum that one must have in order to believe that curriculum revision will bring about drastic improvements in student achievement. In the same speech, however, Cox presented data that cast doubt on her own statement: Whereas 47% of Black and 46% of Hispanic 8th graders did not meet minimum standard requirements on the CRCT mathematics test, only 19% of White students failed to do so. This is in spite of the fact that all students in Georgia were being taught under the QCCs.

Part of this disparity was likely the difference in what was intended to be taught, as codified by the curriculum framework, and what was actually taught in schools throughout the state. Replacing the QCCs with a new framework, however, does nothing

to address this issue of disparity in what reaches classrooms—the previously ignored curriculum would just be replaced with a new ignored curriculum.

In the PISA 2003 study, males outperformed females in mathematics in two-thirds of the countries studied, and three-fourths of countries examined had weaker correspondences between socioeconomic status and mathematics performance than did the United States. Clearly there are powerful influences having nothing to do with curriculum frameworks at work here, and Georgia must carefully examine and address these influences if it is to create an educational system that is both equitable and effective for all of its citizens.

This very issue was well addressed in *Everybody Counts* (Mathematical Sciences Education Board, 1989):

Why not just imitate Japan?

International studies of mathematics and science education show that, when compared with students in other countries, U.S. students do very poorly while Japanese students do very well. One natural response, therefore, is to think that we could improve our educational system by imitating Japan.

These same studies, however, document that the social context of education has a greater influence on student performance than does actual classroom practice. Parental attitudes, student expectations, and teacher self-respect are among the most significant factors in quality education and they depend uniquely on culture.

Imitating others is no solution... (p. 90)

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Appendix A: The 1989 Japanese Mathematics Guidelines for Grades 6-8

The following is my translation of the “6th year” section of the “Arithmetic” chapter of the 1989 Primary School Guidelines for Learning and Instruction and the “7th year” and “8th year” sections of the 1989 Junior High School Guidelines for Learning and Instruction (Japan Ministry of Education, 1989a, 1989b).

In the original documents, there is a Section 3, “Handling of the Content,” which contains notes concerning how specific areas of the curriculum should be delivered. I have taken the liberty of including the content of that section in Section 2, “Content”, to make comparison with the Georgia standards easier. The lines from that section are marked “Note:” in square brackets.

Grade 6

1. Goals

- (1) To understand fraction multiplication and division, to learn how to use those operations, and to deepen students’ understanding of multiplication and division.
- (2) To teach students how to find the volume of basic geometric figures. To teach students about systems of measurement, and how to perform measurements efficiently.

- (3) To deepen students' understanding of geometric shapes by focusing on symmetry.
- (4) To extend the idea of functions through understanding of proportions, and to use that concept effectively to consider quantitative relationships. To learn to make statistical observations and expressions through observation of data distributions, etc.

2. Content

A. Numbers and calculation

- (1) Students will understand the meaning of multiplication and division of rational numbers, extend their abilities to perform these functions, and deepen their understanding of multiplication and division. [Note: Insure that students understand that relationships shown by equations, etc., are also valid when fractions are used.]
 - a. Students will grasp the meaning of multiplication and division, both when the numbers involved are integers and when they are rational numbers.
 - b. Students will learn the method of calculation of multiplication and division problems involving rational numbers.
 - c. Students will understand division as multiplication by reciprocals of fractions.
 - d. Students will be able to re-write multiplication and division of integer and decimal numbers as problems involving fractions. Also, they will learn to represent multiplication and division problems as a single fraction.

B. Quantities and measurements

[Note: Lessons for this section should make efforts to use letter variables such as a , x , etc. so as to allow students to become used to them.]

- (1) Students will learn to find the volume and other properties of basic solid objects through experimentation, direct measurement, etc.
 - a. Students will learn how to find the volume and surface area of basic prisms and cylinders.
 - b. Students will learn how to find the volume of basic pyramid and cone solids, and in simple cases to find their surface areas. [Note: The solids used should be simple enough so that an exploded diagram of the shapes can be easily drawn. The cones for which surface area is found should be simple ones with exploded sides that are half circles, quarter circles, etc.]
- (2) Students will deepen their understanding of performing measurements and units, and improve their abilities to make measurements.
 - a. Students will make efficient measurements using proportional measurements, etc.
 - b. Students will understand the metric system and its system of units, and use it effectively to make measurements. [Note: the units kiloliter (kl), milligram (mg), and ton (t) should also be briefly mentioned.]

C. Figures

- (1) Students will further deepen their understanding of plane figures.
 - a. Students will understand the meaning of point and line symmetries, and consider the symmetries of basic geometric figures.

- b. Students will round out their understanding of the shape and size of figures, learning to recognize and draw simple rescalings of figures.
- (2) Students will deepen their understanding of basic solid figures through manipulations such as construction and decomposition. [Note: Students should learn to read and create appropriate sketches and exploded diagrams, and in simple cases how to read and create 2- and 3-dimensional diagrams.]
- a. Students will learn about basic prisms and cylinders.
 - b. Students will learn about basic pyramid and cone solids.

D. Quantitative relationships

[Note: Lessons for this section should make efforts to use letter variables such as a , x , etc., so as to allow students to become used to them.]

- (1) Students will learn the meaning of ratios and how to use them.
- (2) Students will improve their abilities to observe the relationship between two mutually changing quantities.
 - a. Students will understand the meaning of proportion. Students will also learn to use mathematical expressions and graphs to examine the features of such relationships. [Note: Graphs of proportional relationships should be constructed so as to gradually call attention to the continuous change between the quantities and the range under which the change occurs.]
 - b. Students will understand the meaning of inverse proportion. Students will also learn to use mathematical expressions to represent simple examples. [Note: Graphs of inverse proportions should be only complex enough so that a broken-line graph can show the change between the two quantities in question.]

(3) Students will learn to examine simple examples of data scatter, and how to examine and represent it statistically.

- a. Students will learn about tables and graphs that show frequency distributions.
- b. Students will learn that proportions of a sample of data can give information about the tendencies of the entire body of data.
- c. Students will learn to select and adapt the table or graph that is most appropriate to their goals.

(4) Students should gradually be taught that for simple matters possible cases can be ordered and examined.

Terms and symbols

Reciprocal, bottom face, side face, axis of symmetry, center of symmetry, greater than or equal, less than, : (in ratios)

Grade 7

1. Goals

- (1) Students' concept of numbers will be deepened by extension to include positive and negative numbers. Students will also understand the motivation for using letter variables and the meaning of equations, while learning to use them to generalize and succinctly show relationships.
- (2) Students will deepen their instinctive view and ideas of geometric figures through manipulation and experimentation with plane and spatial diagrams, and in so doing develop a foundation for logical thought.
- (3) Students will deepen their view and thinking of change and correspondence, understand functional relationships, and improve their ability to express and use them.

2. Content

A. Numbers and expressions

- (1) Students will understand positive and negative numbers, and learn how to use the four basic arithmetic operations with them. [Note: The possibility of performing the four arithmetic operations should be discussed.]
- (2) Students will develop their ability to express relationships and laws by using letter variables in mathematical expressions, and learn how to perform calculations using simple equations.
 - a. Students will use letter variables.
 - b. Students will learn how multiplication and division are represented in expressions that include letter variables.

- c. Students will learn how to add and subtract linear equations. [Note: Discussion should only be of depth required to solve calculations involving single-variable linear equations]
- (3) Students will understand the meaning of equations, and learn how to use single-variable linear equations.
- a. The meaning of the solution to a letter variable found in an equations
 - b. The properties of equalities
 - c. The solution to single-variable linear equations

Terms and symbols

Natural number, sign, absolute value, term (of an equation), coefficient, \geq , \leq

B. Figures

- (1) Students will improve their ability to use foresight in constructing basic geometric shapes, and deepen their understanding of plane figures.
- a. Fundamentals of figure construction such as angle bisectors, perpendicular bisectors of line segments, perpendicular lines, etc.
 - b. Parallel translation, symmetric translation, and rotation translation
 - c. The view of geometric figures as a collection of points that meet a certain requirement, and the creation of figures that meet given requirements
- (2) Students will consider geometric figures by performing various operations on them, deepening their understanding of spatial figures.
- a. Positional relationships of lines and planes in space
 - b. The creation of spatial figures by movement of plane figures in space

- c. Cross sections, projections, and explosions of spatial figures [Note: Discussion of technical aspects and applications of cross-sections and projections should not be delved into deeply.]

Terms and symbols

Arc, chord, figure of revolution, π , //, \perp , \angle , \triangle

C. Quantitative relationships

(1) Students will discover quantitative measures that change together in some event, consider and elucidate the relationship between those measures, and understand that relationship as a mathematical function.

- a. Changes and correspondences
- b. The meaning of axis coordinates
- c. Display of a mathematical function in a table, graph, or diagram

(2) Students will deepen their understanding of the equations and graphs of proportions and inverse proportions, and increase their ability to consider and express quantitative relationships. [Note: Discussion should include the construction of accurate graphs.]

Terms and symbols

Variable, range

Grade 8

1. Goals

(1) Students will improve their ability to use and modify equations containing letter variables as needed to suit their goals. Students will understand linear equations and simultaneous equations, and develop their ability to use them.

(2) Students will deepen their understanding of the properties of plane figures. Students will understand the motivation for and methods of mathematical deduction as pertaining to the properties of plane figures, and develop the skills for precise expression in the steps of mathematical deduction.

(3) Students will further deepen their point of view and thoughts pertaining to change and correspondence, understand the properties of linear equations, and develop the skills to use them. Students will also learn how to precisely express numbers as best suited to their goals, and become able to grasp trends in statistical phenomenon.

2. Content

A. Numbers and expressions

(1) Students will learn to perform the four basic arithmetic operations on expressions that include letter variables.

a. Addition and subtraction of simple expressions

b. Multiplication and division of monomial expressions

- (2) Students will further develop their abilities to discover quantitative relationships within phenomena, and use letter variables within equations to express those relationships.
- The use of equations
 - Simple modifications of equalities
- (3) Students will understand the meaning of inequalities, and learn to use single-variable linear inequalities. [Note: Here and in other areas, the process of calculation will be shown in a flow diagram.]
- The meaning of inequalities and their solutions
 - The properties of inequalities
 - Solving single-variable linear inequalities
- (4) Students will understand the meaning of simultaneous systems of equations and their solutions, and learn how to use them.
- The meaning of linear equations in two variables and their solutions
 - How to solve simple systems of simultaneous linear equations [Note: Systems of two equations in two variables will be covered.]

Terms and symbols

Like terms

B. Figures

- (1) Based upon the properties of parallel lines and triangle congruencies, students will learn how to discover the properties of plane figures and prove them.
- The properties of parallel lines
 - The conditions for congruency of triangles

- c. The properties of triangles and parallelograms
- (2) The concept of similarity of triangles will be made clear, and based on the requirements for triangle similarity and congruency students will develop their skills in discovering and proving the properties of plane shapes.
- a. The meaning of similarity and the conditions for triangle similarity.
 - b. The properties of parallel lines and the ratios of line segments.
 - c. Applications of similarity [Note: Applications of similarity will include measurements of height and distance.]

Terms and symbols

Opposing angles, interior angles, exterior angles, definition, proof, center, =, ∞

C. Quantitative relationships

- (1) Students will deepen their understanding of the representation of numbers, and learn to use that knowledge appropriately in real situations. [Note: Binary representation of numbers and representation of numbers as a series of on/off patterns will be covered]
- (2) Students will further deepen their understanding of functional relationships, understand the properties of linear equations, and expand their ability to use them.
- a. Understand that information about phenomenon can be obtained with linear equations
 - b. Understand the properties of the ratio of change and graph of linear equations
 - c. Learn to view linear equations with two variables as an expression of the functional relationship between the variables

(3) Students will learn to collect data according to their goals, how to order that data into tables and graphs, and how to discover trends in the data by observing central tendency, data scattering, etc. [Note: Care should be taken to use actual events from daily life.]

- a. The meaning of frequency distributions and reading histograms
- b. The meaning of relative frequency
- c. The meaning of average value and range
- d. How to read correlation charts and tables

Terms and symbols

Significant figures, approximate value, error, frequency, class

Appendix B: The 1998 Japanese Mathematics Guidelines for Grades 6-8

The following is my translation of the “6th year” section of the “Arithmetic” chapter of the 1998 Primary School Guidelines for Learning and Instruction and the “7th year” and “8th year” sections of the 1998 Junior High School Guidelines for Learning and Instruction (Japan Ministry of Education, 2003c, 2003d).

In the original documents, there is a Section 3, “Handling of the Content,” which contains notes concerning how specific areas of the curriculum should be delivered. I have taken the liberty of including the content of that section in Section 2, “Content,” to make comparison with the Georgia standards easier. The incorporated lines from that section are marked “Note:” in square brackets.

Grade 6

1. Goals

- (1) To deepen students’ understanding of the adding and subtraction of fractions and the appropriate use of these operations, and to understand the meaning of fraction multiplication and division and apply these operations appropriately.

- (2) To have students understand the meaning of volume and learn to find the volume of simple spatial figures, and to learn the meaning of speed and how to calculate speeds.
- (3) To consider and examine the component elements of geometric figures and their positional relationships, and to deepen students' understanding of basic three-dimensional figures.
- (4) To understand the meaning of ratios and proportions, and to come to be able to use the concept of functions in consideration of relationships between quantities.

2. Content

A. Numbers and calculation

- (1) Students will further deepen their understanding of the properties of the integers.
 - a. Students will learn about factors and multiples. [Note: Undue attention should not be paid to finding greatest common factors and least common multiples outside of context – emphasis should be placed on finding them within specific contexts.]
- (2) Students will further deepen their understanding of fractions, understanding the meaning of addition and subtraction of fractions with dissimilar denominators, and learn to use these procedures correctly.
 - a. Students will learn that a fraction obtained by multiplication or division by another fraction having the same number in both the numerator and denominator will result in a fraction representing the same quantity as before.

- b. Students will consider the equivalence of fractions and their relative sizes, and learn to compare the size of fractions.
 - c. Students will consider the calculation of addition and subtraction of fractions with dissimilar denominators, and learn to perform those calculations. [Note: Focus of study should be on addition and subtraction of proper fractions.]
- (3) Students will understand the meaning of multiplication and division of fractions, and learn to apply those techniques appropriately. [Note: Operations with mixed fractions are not to be covered yet.]
- a. Students will understand the meaning of fraction multiplication and division when the multiplier or divisor is a fraction.
 - b. Based upon their understanding of calculation in the case where multipliers or divisors are integers or real numbers, students will understand the meaning of multiplication and division of fractions when the multiplier or divisor is another fraction. [Note: Focus should be on simple cases, such as when the denominator of the multiplier or divisor is one.]
 - c. Students will consider the method of calculation of fraction multiplication and division, and learn to perform those calculations.
- (4) Students will deepen their understanding of approximation.
- a. Students will be able to use approximation to estimate products and quotients as needed.

B. Quantities and measurements

- (1) Students will be able to recognize familiar shapes, and learn to determine their approximate area.
- (2) Students will understand the meaning of volume, and learn to find the volumes of simple shapes.
 - a. Students will understand the meaning of volume measurement and the units used.
 - b. Students will learn the use of cubic centimeters (cm^3) as a unit of volume. [Note: A simple introduction of cubic meters (m^3) as a measurement unit is also appropriate.]
 - c. Students will consider the method of finding volumes of cubes and rectangular parallelepipeds, and learn to do so.
- (3) Students will understand how two different units may be used together to represent a quantity, how to compare and represent such quantities, and learn how to use them.
 - a. Students will make use of the concept of “units per” quantities.
 - b. Students will understand the meaning and representation of speed, think on how speed can be calculated, and perform those calculations.

C. Figures

- (1) Through activities such as observation and construction of geometric figures, students will deepen their understanding of basic solids. Students will learn to consider solids with a focus on component elements and their positional relationships.

- a. Students will understand cubes and right parallelepipeds. [Note: Insure that appropriately simple diagrams and exploded views are used.]
 - b. With regards to right prisms, students will understand the relationships between parallel and perpendicular lines and planes.
 - c. Students will learn about prism shapes with three and four sides, and about cylinders. [Note: Exploded views, elevation diagrams, and plane diagrams are not to be used.]
- D. Quantitative relationships
- (1) Students will understand the meaning of ratios in simple situations. [Note: Investigations should be of quantitative relationships in specific contexts, and should focus on understanding that equivalent ratios exist – their numeric value is not to be found.]
 - (2) Students will improve their abilities to observe the relationship between two changing quantities.
 - a. Students will understand the meaning of proportion. Students will learn how to find the features of simple proportions by using tables and graphs.
 - (3) Students will learn the meaning of averages, and how to use them.

Terms and symbols

Greatest common divisor, least common multiple, reduction of fractions, reduction to a common denominator, plane, bottom plane, side plane, : (as ratio)

Grade 7

1. Goals

- (1) Students' concept of numbers will be deepened by extension to include positive and negative numbers. Students will also understand the motivation for using letter variables and the meaning of equations, while learning to use them to generalize and succinctly show relationships.
- (2) Students will deepen their instinctive view and ideas of geometric figures through observation, manipulation, and experimentation with plane and spatial diagrams, and in so doing develop a foundation for logical thought.
- (3) To deepen understanding of direct and inverse proportions through investigation of specific phenomena, and to develop a basis for their observation by expressing quantitative relationships.

2. Content

A. Numbers and expressions

- (1) Students will understand the role of positive and negative numbers in specific situations, and learn to perform the basic arithmetic operations using them.
 - a. Students will learn the necessity of negative numbers, and understand the meaning of positive numbers and negative numbers.
 - b. Students will learn the meaning of performing the basic arithmetic operations using both positive and negative numbers, and be able to perform simple calculations.

- (2) Students will learn how to add and subtract linear equations. [Note: Discussion should only be of depth required to solve calculations involving single-variable linear equations]
- a. Students will understand the motivation for using letters in expressions.
 - b. Students will learn how multiplication and division are represented in expressions that include letter variables.
 - c. Students will learn to add and subtract linear equations. [Note: Methods for calculating equations will be learned only up to the degree necessary to perform this.]
- (3) Students will understand equations, and learn how to use linear equations.
- a. Students will understand the meaning of expressions and letters contained in them, and of the solutions to those letters.
 - b. Students will discover the properties of statements of equality, and learn that equations can be solved based on those properties.
 - c. Students will learn to solve simple linear equations, and to use them.

Terms and Symbols

Integer, sign, absolute value, term (of an equation), coefficient, <, >, ≤, ≥

B. Figures

- (1) Students will improve their abilities in using foresight to construct basic geometric shapes, and deepen their understanding of plane figures. [Note: The fact that a line tangent to a circle is perpendicular to the radius touching the point of tangency must be covered.]

- a. Students will understand the meaning of line and point symmetry, and deepen their intuitive sense and thinking of geometric figures by focusing on symmetry.
 - b. Students will learn of the fundamentals of geometric shape construction such as angle bisector, the perpendicular bisector of a line segment, and perpendicular lines, and learn to use them.
- (2) Students will deepen their understanding of spatial figures by consideration of their observation, manipulation, and experimentation. Students will also improve their skills at measurement of figures.
- a. Students will learn the positional relationships of lines and planes in three-dimensional space.
 - b. Students will learn that solid shapes are constructed by manipulation of lines and planes in space, and how to represent three-dimensional objects on a flat surface. [Note: Cross-sections and projections will not be covered.]
 - c. Students will learn to find the length of the arc of a circular wedge, the surface area of a circular wedge, and the surface areas and volumes of basic cylinders and cones. [Note: Cylinders and cones having only basic shapes such as triangles and circles must be covered.]

Terms and symbols

Arc, chord, solid of revolution, π , //, \perp , \angle , Δ

C. Quantitative relationships

- (1) Through investigation and consideration of the changes and correspondences of two quantities found within a specific phenomenon, students will improve their ability to discover direct and inverse proportions and to express them.
- a. Students will understand the meanings of direct and inverse proportion.
 - b. Students will understand the meaning of coordinates.
 - c. Students will understand how direct and inverse proportions can be represented in tables, equations, graphs, etc., and the features of each.
 - d. Students will put into use the idea and concept of direct and indirect proportions.

Terms and Symbols

Variable, codomain

Grade 8

1. Goals

- (1) Students will improve their ability to use and modify equations containing letter variables as needed to suit their goals. Students will simultaneous equations, and develop their ability to use them.
- (2) Students will deepen their understanding of the properties of basic plane figures through observation, manipulation, and experimentation. Also, students will understand the motivation and method of mathematical induction through consideration of the properties of geometric figures, and develop their ability to make precise statements in the process of mathematical induction.
- (3) To understand linear equations through the investigation of specific phenomena, and to develop the ability to discover, express, and observe functional relationships. Also, to develop a basis for thinking about probability through observation of and experimentation with specific phenomena.

2. Content

A. Numbers and expressions

- (1) Students will improve their ability to discover quantitative functions within phenomena, and to use letter variables to express them as expressions that use letter variables. Students will also learn to perform the four basic arithmetic operations on expressions that include letter variables.

- a. Students will learn to perform addition and subtraction of simple polynomial expressions, and multiplication and division of monomial expressions.
 - b. Students will understand that expressions using letter variables can be used to represent quantities and quantitative relationships.
 - c. Students will learn to modify simple expressions to suit their needs.
- (2) Students will understand the concept of simultaneous systems of equations in two variables, and to learn to use them.
- a. Students will understand the meaning of a linear equation in two variables, and its solution.
 - b. Students will understand the meaning of a system of linear equations in two variables, and how to solve simple systems of linear equations in two variables, and how they are used. [Note: Systems of simultaneous equations of the form $A = B = C$ will not be covered.]

Terms and symbols

like terms

B. Figures

- (1) Students will discover the properties of basic plane figures through observation, manipulation, and experimentation and learn to confirm them using the properties of parallel lines.
- a. Students will understand the properties of parallel lines and angles, and based on that confirm the properties of basic figures.
 - b. Based upon the properties of parallel lines and the angles of triangles, students will discover the properties of the angles of polygons.

- (2) Students will confirm the basic properties of plane figures based upon the conditions of congruency of triangles, and develop their ability to make logical observations.
- a. Students will understand the motivation for and method of mathematical proofs.
 - b. Students will understand the conditions for triangle congruency, and based upon that learn to use mathematical logic to confirm the properties of triangles and parallelograms. [Note: When squares, diamonds, and rectangles are examined, they will only be presented as special cases of parallelograms.]
 - c. Students will use observation and experimentation to discover the relationship between the central and peripheral angles of regular polygons, and learn that these relationships can be logically confirmed. [The converse case of the theorem of peripheral angles will not be covered.]

Terms and symbols

Angles of intersection, interior angles, exterior angles, definition, proof, \equiv

C. Quantitative relationships

- (1) Students will understand linear functions by taking two quantities from a specific phenomenon and examining how they correspond, developing their ability to discover functional relationships, and to express and consider them.
- a. Students will learn that information about phenomenon can be obtained with linear equations.

- b. Students will learn to find the slope of the graph of a linear function and the features of such graphs, and how to use linear functions.
 - c. Students will learn to view an equation in two variables as an expression that can be resolved as a function. [Note: The case where $x = h$ will not be covered.³]
- (2) Students will understand probability through observation and experimentation of specific phenomena.
- a. Students will be able to systematically show sample spaces. [Note: Only simple cases such as those where the sample space can be shown as a tree diagram will be covered.]
 - b. Students will understand probability as an expression of the likelihood of occurrence of an undetermined event, and learn to find the probability of simple events. [Note: Finding a probability as the complement of an event will not be covered.]

³ In other words, the case where $b = 0$ in the expression $ax + by + c = 0$, and therefore x will equal a constant. (MEXT, 1998)

Appendix C: A Comparison of the 1989 and 1998 Japanese

Guidelines for Grades 6-8

Grade 6

The following is a direct comparison showing the changes made in the 1998 revision of the 1989 Japanese Guidelines for Learning and Instruction for 6th grade math.

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>1. Goals</p> <p>(1) To understand fraction multiplication and division, to learn how to use those operations, and to deepen students' understanding of multiplication and division.</p> <p>(2) To teach students how to find the volume of basic geometric figures. To teach students about systems of measurement, and how to perform measurements efficiently.</p> <p>(3) To deepen students' understanding of geometric shapes by focusing on symmetry.</p>	<p>1. Goals</p> <p>(1) To deepen students' understanding of the adding and subtraction of fractions and the appropriate use of these operations, and to understand the meaning of fraction multiplication and division and apply these operations appropriately.</p> <p>(2) To have students understand the meaning of volume and learn to find the volume of simple spatial figures, and to learn the meaning of speed and how to calculate speeds.</p> <p>(3) To consider and examine the component elements of geometric figures and their positional relationships, and to deepen students' understanding of basic three-dimensional figures.</p>	<p>Review of fraction addition and subtraction added.</p> <p>"Basic geometric figures" replaced with "simple spatial figures"; "measurements" replaced by "speed".</p> <p>All mention of symmetry dropped; "positional relationships" is a carry-over topic begun in 5th grade.</p>

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>(4) To extend the idea of functions through understanding of proportions, and to use that concept effectively to consider quantitative relationships. To learn to make statistical observations and expressions through observation of data distributions, etc.</p>	<p>(4) To understand the meaning of ratios and proportions, and to come to be able to use the concept of functions in consideration of relationships between quantities.</p>	<p>Statistics thread dropped.</p>
<p>2. Content A. Numbers and calculation</p>	<p>2. Content A. Number and calculation (1) Students will further deepen their understanding of the properties of the integers.</p>	<p>Moved up from the previous 5th grade curriculum</p>
<p>(1) Students will understand the meaning of multiplication and division of rational numbers, extend their abilities to perform these functions, and deepen their understanding of multiplication and division. [Note: It will be necessary to insure that the fact that the relationship shown by equations, etc. is also used with fractions is mentioned.]</p>	<p>(2) Students will further deepen their understanding of fractions, understanding the meaning of addition and subtraction of fractions with dissimilar denominators, and learn to use these procedures correctly.</p>	
	<p>a. Students will learn that a fraction obtained by multiplication or division by another fraction having the same number in both the numerator and denominator will result in a fraction representing the same quantity as before.</p>	<p>Moved up from the previous 5th grade curriculum</p>

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>a. Students will grasp the meaning of multiplication and division, both when the numbers involved are integers and when they are rational numbers.</p> <p>b. Students will learn the method of calculation of multiplication and division problems involving rational numbers.</p> <p>c. Students will try performing division as a multiplication problem using reciprocals of fractions.</p> <p>d. Students will be able to re-write multiplication and division of integer and decimal numbers as problems involving fractions. Also, they will learn to represent multiplication and division problems as a single fraction.</p>	<p>b. Students will consider the equivalence of fractions and their relative sizes, and learn to compare the size of fractions.</p> <p>c. Students will consider the calculation of addition and subtraction of fractions with dissimilar denominators, and learn to perform those calculations. [Note: Focus of study should be on addition and subtraction of proper fractions.]</p>	<p>Moved up from the previous 5th grade curriculum</p> <p>Moved up from the previous 5th grade curriculum</p> <p>Removed.</p> <p>Removed.</p> <p>Removed.</p>

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>B. Quantities and measurements [Note: Lessons for this section should make efforts to use letter variables such as a, x, etc. so as to allow students to become used to them.]</p> <p>(1) Students will learn to find the volume and other properties of basic solid objects through experimentation, direct measurement, etc.</p> <p>a. Students will learn how to find the volume and surface area of basic prisms and cylinders.</p>	<p>B. Quantities and measurements</p> <p>(1) Students will be able to recognize familiar shapes, and learn to determine their approximate area.</p> <p>(2) Students will understand the meaning of volume, and learn to find the volumes of simple shapes.</p> <p>a. Students will understand the meaning of volume measurement and the units used.</p> <p>b. Students will learn the use of cubic centimeters (cm^3) as a unit of volume. [Note: A simple introduction of cubic meters (m^3) as a measurement unit is also appropriate.]</p> <p>c. Students will consider the method of finding volumes of cubes and right parallelepipeds, and learn to do so.</p>	<p>Note removed.</p> <p>Moved up from the previous 5th grade curriculum.</p> <p>Moved up from the previous 5th grade curriculum.</p> <p>Moved up from the previous 5th grade curriculum. (In the 1988 curriculum, both cm^3 and m^3 were prescribed – here m^3 is optional)</p> <p>This appears to be a simplification of the previous B.(1)a (see below).</p> <p>“Experimentation and measurement” element removed.</p> <p>“Prisms and cylinders” simplified to “cubes and right parallelepipeds” (see B.(2)b, above).</p>

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>b. Students will learn to find the volume of basic pyramids and cones, and in simple cases to find their surface areas. [Note: The solids used should be simple enough so that an exploded diagram of the shapes can be easily drawn. The cones for which surface area is found should be simple ones with side shapes that are half circles, quarter circles, etc.]</p>		Removed.
<p>(2) Students will deepen their understanding of performing measurements and units, and improve their abilities to make measurements.</p>	<p>(3) Students will understand how two different units may be used together to represent a quantity, how to compare and represent such quantities, and learn how to use them.</p>	<p>“Understanding of units” was removed, as was the skill-focused “ability to make measurements”.</p>
<p>a. Students will make efficient measurements using proportional measurements, etc.</p>	<p>a. Students will make use of the concept of “units per” quantities.</p>	
<p>b. Students will understand the metric system and its system of units, and use it effectively to make measurements. [Note: The units kiloliter (kl), milligram (mg), and ton (t) should also be briefly mentioned.]</p>	<p>b. Students will understand the meaning and representation of speed, think on how speed can be calculated, and perform those calculations.</p>	<p>Concept of “proportional measurement” replaced with “‘units per’ quantities”. While the concept remains the same, the presentation has been simplified. Only speed is specified, where once the entire metric system was taught.</p>
<p>C. Geometric figures (1) Students will further deepen their understanding of plane figures.</p>		Removed.

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>a. Students will understand the meaning of point and line symmetries, and consider the symmetries of basic geometric figures.</p> <p>b. Students will round out their understanding of the shape and size of figures, learning to recognize and draw simple rescalings of figures.</p> <p>(2) Students will deepen their understanding of basic solid figures through manipulations such as construction and decomposition. [Note: Students should learn to read and create appropriate sketches and exploded diagrams, and in simple cases how to read and create 2- and 3-dimensional diagrams.]</p> <p>a. Students will learn about basic prisms and cylinders.</p> <p>b. Students will learn about basic pyramids and cones</p>	<p>(1) Through activities such as observation and construction of geometric figures, students will deepen their understanding of basic solids. Students will learn to consider solids with a focus on component elements and their positional relationships.</p> <p>a. Students will understand cubes and right parallelepipeds. [Note: Insure that appropriately simple diagrams and exploded views are used.]</p> <p>b. With regards to right prisms, students will understand the relationships between parallel and perpendicular lines and planes.</p> <p>c. Students will learn about prism shapes with three and four sides, and about cylinders. [Note: Exploded views, elevation diagrams, and plane diagrams are not to be used.]</p>	<p>Removed.</p> <p>Removed.</p> <p>As in B.(1)a, objects studied have been simplified.</p> <p>Cones removed.</p>

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>D. Quantitative relationships [Note: Lessons for this section should make efforts to use letter variables such as a, x, etc. so as to allow students to become used to them.]</p> <p>(1) Students will learn the meaning of ratios and how to use them.</p> <p>(2) Students will improve their abilities to observe the relationship between two mutually changing quantities.</p> <p>a. Students will understand the meaning of proportion. Students will also learn to use mathematical expressions and graphs to examine the features of such relationships. [Note: Graphs of proportional relationships should be constructed so as to show step-by-step the continuous change between the quantities, and the range under which the change occurs.]</p>	<p>D. Quantitative relationships</p> <p>(1) Students will understand the meaning of ratios in simple situations. [Note: Investigations should be of quantitative relationships in specific contexts, and should focus on understanding that equivalent ratios exist – their numeric value is not to be found.]</p> <p>(2) Students will improve their abilities to observe the relationship between two mutually changing quantities.</p> <p>a. Students will understand the meaning of proportion. Students will learn how to find the features of simple proportions by using tables and graphs.</p>	<p>Note removed.</p> <p>Students will now “understand the meaning of ratios”, but “in simple situations” has been added and “how to use them” removed.</p> <p>Understanding how to “use mathematical expressions” to express proportions removed. Note removed.</p>

1988 Japanese Standard	1998 Japanese Standard	Comments
<p>b. Students will understand the meaning of inverse proportion. Students will also learn to use mathematical expressions to represent simple examples. [Note: Graphs of inverse proportions should be only complex enough so that a broken-line graph can show the change between the two quantities in question.]</p> <p>(3) Students will learn to examine simple examples of data scatter, and how to examine and represent it statistically.</p> <p>a. Students will learn about tables and graphs that show frequency distributions.</p> <p>b. Students will learn that proportions of a sample of data can give information about the tendencies of the entire body of data.</p> <p>c. Students will learn to select and adapt the table or graph that is most appropriate to their goals.</p> <p>(4) Students should gradually be taught that for simple matters possible cases may be ordered and examined.</p>	<p>(3) Students will learn the meaning of averages, and how to use them</p>	<p>Inverse proportions moved to 7th grade.</p> <p>All content related to statistics and data analysis replaced with only "averages".</p>

Grade 7

The following is a direct comparison showing the changes made in the 1998 revision of the 1989 Japanese Guidelines for Learning and Instruction for 7th grade math.

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>1. Goals (1) Students' concept of numbers will be deepened by extension to include positive and negative numbers. Students will also understand the motivation for using letter variables and the meaning of equations, while learning to use them to generalize and succinctly show relationships. (2) Students will deepen their instinctive view and ideas of geometric figures through manipulation and experimentation with plane and spatial diagrams, and in so doing develop a foundation for logical thought. (3) Students will deepen their view and thinking of change and correspondence, understand functional relationships, and improve their ability to express and use them.</p>	<p>1. Goals (1) Students' concept of numbers will be deepened by extension to include positive and negative numbers. Students will also understand the motivation for using letter variables and the meaning of equations, while learning to use them to generalize and succinctly show relationships. (2) Students will deepen their instinctive view and ideas of geometric figures through observation, manipulation, and experimentation with plane and spatial diagrams, and in so doing develop a foundation for logical thought. (3) Students will deepen their understanding of direct and inverse proportions through investigation of specific phenomena, and to develop fundamental skills of observation and expression of quantitative relationships.</p>	<p>No change.</p> <p>No substantial change ("observation" added).</p> <p>The general "change and correspondance" replaced with the more specific "direct and inverse proportions", which was previously assumed complete in the 6th grade. Under the new standards this is the first introduction of inverse proportions.</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>2. Content A. Numbers and expressions (1) Students will understand positive and negative numbers, and learn how to use the four basic arithmetic operations with them. [Note: Reasoning for the possibility of performing the four arithmetic operations should be discussed.]</p> <p>(2) Students will develop their ability to express relationships and laws by using letter variables in mathematical expressions, and learn how to perform calculations using simple equations.</p> <p>a. Students will use letter variables.</p> <p>b. Students will learn how multiplication and division are represented in expressions that include letter variables.</p>	<p>2. Content A. Numbers and expressions (1) Students will understand the role of positive and negative numbers in actual situations, and learn to perform the basic arithmetic operations using them.</p> <p>a. Students will learn the necessity of negative numbers, and understand the meaning of positive numbers and negative numbers.</p> <p>b. Students will learn the meaning of performing the basic arithmetic operations using both positive and negative numbers, and be able to perform simple calculations.</p> <p>(2) Students will develop their skills in using letter variables to express relationships and rules, and learn to use equations that involve letter variables to perform calculations. [Note: Where the value of a letter variable is to be calculated, only equations in one variable will be used.]</p> <p>a. Students will understand the motivation for using letters in expressions.</p> <p>b. Students will learn how multiplication and division are represented in expressions that include letter variables.</p>	<p>The new curriculum specifies that “real world” situations should be used. The note was clarified and re-written as A.(1)a-b, below.</p> <p>This is a clarification and re-write of what was previously an explanatory note.</p> <p>Shift in focus from procedural skill to understanding of content. Unchanged.</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>c. Students will learn how to add and subtract linear equations. [Note: Discussion should only be of depth required to solve calculations involving single-variable linear equations]</p> <p>(3) Students will understand the meaning of equations, and learn how to use single-variable linear equations.</p> <p>a. The meaning of letter variables found in an equation, and their solution.</p> <p>b. The properties of equality</p> <p>c. The solution to single-variable linear equations</p>	<p>c. Students will learn how to add and subtract linear equations. [Note: Discussion should only be of depth required to solve calculations involving single-variable linear equations]</p> <p>(3) Students will understand equations, and learn how to use linear equations.</p> <p>a. Students will understand the meaning of equations, the letters contained in them, and of the solutions to equations.</p> <p>b. Students will discover the properties of statements of equality, and learn that equations can be solved based on those properties.</p> <p>c. Students will learn to solve simple linear equations, and how to use them.</p>	<p>Unchanged.</p> <p>No substantial change.</p> <p>No substantial change.</p> <p>Note the shift to the constructivist idea of “discovery”.</p> <p>Added focus on “real-world” skills.</p>
<p>B. Figures</p> <p>(1) Students will improve their ability to use foresight in constructing basic geometric shapes, and deepen their understanding of plane figures.</p> <p>a. Fundamentals of figure construction such as angle bisectors, perpendicular bisectors of line segments, perpendicular lines, etc.</p>	<p>B. Figures</p> <p>(1) Students will improve their ability to use foresight in constructing basic geometric shapes, and deepen their understanding of plane figures. [Note: The fact that a line tangent to a circle is perpendicular to the radius touching the point of tangency must be covered.]</p> <p>b. Students will learn of the fundamentals of geometric shape construction such as the angle bisectors, the perpendicular bisector of a line segment, and perpendicular lines, and learn to use them.</p>	<p>Note added.</p> <p>No substantial change.</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
b. Parallel translation, symmetric translation, and rotational translation		Removed.
	a. Students will understand the meaning of line and point symmetry, and deepen their intuitive sense and thinking of geometric figures by focusing on symmetry.	This was taught in the 6th grade under the previous curriculum.
c. The view of geometric figures as a collection of points that meet a certain requirement, and the creation of figures that meet given requirements		Removed.
(2) Students will consider geometric figures by performing various operations on them, deepening their understanding of spatial figures.	(2) Students will deepen their understanding of spatial figures by consideration of their observation, manipulation, and experimentation. Students will also improve their skills at measurement of figures.	It is interesting that “measurement skills” was removed from B.(2) of the 6th grade standards, yet added here.
a. Positional relationships of lines and planes in space	a. Students will learn the positional relationships of lines and planes in three-dimensional space.	No substantial change.
b. The creation of spatial figures by movement of plane figures in space	b. Students will learn that solid shapes are constructed by manipulation of lines and planes in space, and how to represent three-dimensional objects on a flat surface. [Note: Cross-sections and projections will not be covered.]	Clarification.
c. Cross sections, projections, and explosions of spatial figures [Note: Discussion of technical aspects and applications of cross-sections and projections should not be delved into deeply.]		Removed.

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>C. Quantitative relationships (1) Students will discover quantitative measures that change together in some event, consider and elucidate the relationship between those measures, and understand that relationship as a mathematical function.</p> <p>a. Changes and correspondences</p> <p>b. The meaning of axis coordinates</p> <p>c. Display of a mathematical function in a table, graph, or diagram</p>	<p>c. Students will learn to find the length of an arc, and the surface area and volume of pyramids and cones. [Note: Cylinders and cones having only bases of basic shapes such as triangles and circles will be covered.]</p> <p>C. Quantitative relationships (1) Through investigation and consideration of the changes and correspondences of two quantities found within a specific phenomenon, students will improve their ability to discover direct and inverse proportions and to express them.</p> <p>a. Students will understand the meanings of direct and inverse proportion.</p> <p>b. Students will understand the meaning of coordinates.</p> <p>c. Students will understand how direct and inverse proportions can be represented in tables, equations, graphs, etc., and the features of each.</p> <p>d. Students will put into use the idea and concept of direct and indirect proportions.</p>	<p>Cones moved here from 6th grade.</p> <p>Addition of “real world” language (“specific phenomenon”), removal of requirement that students see relationships as a function.</p> <p>As under “Goals”, “changes and correspondences” replaced with “direct and inverse proportion”. No substantial change.</p> <p>“Function” terminology moved to 8th grade; addition of “features” of tables, graphs, etc.</p> <p>This is an additional call for learning “real-world” applications (the Commentary to these guidelines mentions using examples from science courses, and relationships between side length and area of plane figures).</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>(2) Students will deepen their understanding of the equations and graphs of proportions and inverse proportions, and increase their ability to consider and express quantitative relationships. [Note: Discussion should include the construction of accurate graphs.]</p>		<p>Removed, but to an extent covered by C.(1).c.</p>

Grade 8

The following is a direct comparison showing the changes made in the 1998 revision of the 1989 Japanese Guidelines for Learning and Instruction for 8th grade math.

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>1. Goals</p> <p>(1) Students will improve their ability to use and modify equations containing letter variables as needed to suit their goals. Students will understand linear equations and simultaneous equations, and develop their ability to use them.</p> <p>(2) Students will deepen their understanding of the properties of plane figures. Students will understand the motivation for and methods of mathematical induction as pertaining to the properties of plane figures, and develop the skills for precise expression in the steps of mathematical induction.</p> <p>(3) Students will further deepen their understanding and thoughts pertaining to change and correspondence, understand the properties of linear equation, and develop the skills to use them. Students will also learn how to precisely express numbers as best suited to their goals, and become able to grasp trends in statistical phenomenon.</p>	<p>1. Goals</p> <p>(1) Students will improve their ability to use and modify equations containing letter variables as needed to suit their goals. Students will understand simultaneous equations, and develop their ability to use them.</p> <p>(2) Students will deepen their understanding of the properties of basic plane figures through observation, manipulation, and experimentation. Also, students will understand the motivation and method of mathematical induction through consideration of the properties of geometric figures, and develop their ability to make precise statements in the process of mathematical induction.</p> <p>(3) Students will understand linear equations through the investigation of specific phenomena, and to develop their ability to discover, express, and observe functional relationships. Also, students will develop a basis for thinking about probability through observation of and experimentation with specific phenomena.</p>	<p>No substantial change.</p> <p>No substantial change.</p> <p>As in previous grades, “change and correspondence” terminology removed. “Function” terminology moved here from 6th grade. Some probability retained, but most statistics content removed (see below).</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>2. Content A. Numbers and calculations (1) Students will learn to perform the four basic arithmetic operations on expressions that include letter variables.</p> <p>a. Addition and subtraction of simple expressions</p> <p>b. Multiplication and division of monomial expressions (2) Students will further develop their abilities to discover quantitative relationships within phenomena, and use letter variables within equations to express those relationships.</p> <p>a. The use of equations</p> <p>b. Simple modifications of equations</p> <p>(3) Students will understand the meaning of inequalities, and learn to use single-variable linear equations. [Note: Here and in other areas, the process of calculation will be shown in a flow diagram.]</p>	<p>2. Content A. Numbers and expressions (1) Students will improve their ability to discover quantitative functions within phenomena, and to use letter variables to express them as expressions that use letter variables. Students will also learn to perform the four basic arithmetic operations on expressions that include letter variables.</p> <p>a. Students will learn to perform addition and subtraction of simple polynomial expressions, and multiplication and division of monomial expressions.</p> <p>b. Students will understand that expressions using letter variables can be used to represent quantities and quantitative relationships.</p> <p>c. Students will learn to modify simple expressions to suit their needs.</p>	<p>Function terminology moved here from 7th grade under the previous curriculum.</p> <p>2.A.(1).a and 2.A.(1).b combined.</p> <p>Combined with above.</p> <p>This item was re-written for clarity and combined with 2.A.(1), above.</p> <p>Re-write for clarity.</p> <p>Re-write for clarity.</p> <p>Content related to inequalities removed. Deletion of the note means that there is no longer instruction to create flow diagrams to show methods of calculation (perhaps to avoid over-emphasis of procedural skills).</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
a. The meaning of inequalities and their solutions		Removed.
b. The properties of inequalities		Removed.
c. Solving single-variable linear inequalities		Removed.
(4) Students will understand the meaning of simultaneous systems of equations and their solutions, and learn how to use them.	(2) Students will understand the meaning of simultaneous systems of equations in two variables, and to learn to use them.	No substantial change.
a. The meaning of linear equations in two-variables and their solutions	a. Students will understand the meaning of a linear equation in two variables, and its solution.	No substantial change.
b. How to solve simple systems of simultaneous linear equations [Note: Systems of two equations in two variables will be covered.]	b. Students will understand the meaning of a system of linear equations in two variables, how to solve simple systems of linear equations in two variables, and how they are used. [Note: Systems of simultaneous equations of the form $A = B = C$ will not be covered.]	No substantial change. Previous note deleted, new note added.
B. Figures	B. Figures	Though left aligned in this table, this section of the standards was completely re-written. While the focus of this section remains the same – students will use properties of parallel lines and congruent triangles to begin writing geometric proofs – the new standards go into far greater detail as to what will be taught, and how. Section re-written (see above).
(1) Based upon the properties of parallel lines and triangle congruencies, students will learn how to discover the properties of plane figures and prove them.	(1) Students will discover the properties of basic plane figures through observation, manipulation, and experimentation and learn to confirm them using the properties of parallel lines.	
a. The properties of parallel lines	a. Students will understand the properties of parallel lines and angles, and based on that confirm the properties of basic figures.	

1989 Japanese Standard	1998 Japanese Standard	Comments
b. The conditions for congruency of triangles	b. Based upon the properties of parallel lines and the angles of triangles, students will discover the properties of the angles of polygons.	Section re-written (see above).
c. The properties of triangles and parallelograms	(2) Students will confirm the basic properties of plane figures based upon the conditions of congruency of triangles, and develop their ability to make logical observations.	Section re-written (see above).
(2) The concept of similarity of triangles will be made clear, and based on the requirements for triangle similarity and congruency students will develop their skills in discovering and proving the properties of plane shapes.	a. Students will understand the motivation for and method of mathematical proofs.	Section re-written (see above).
a. The meaning of similarity and the conditions for triangle similarity.	b. Students will understand the conditions for triangle congruency, and based upon that learn to use mathematical logic to confirm the properties of triangles and parallelograms. [Note: When squares, diamonds, and rectangles are examined, they will only be presented as special cases of parallelograms.]	Section re-written (see above).
b. The properties of parallel lines and the ratios of line segments.	c. Students will use observation and experimentation to discover the relationship between the central and peripheral angles of polygons, and learn that these relationships can be logically confirmed. [The converse case of the theorem of peripheral angles will not be covered.]	Section re-written (see above).

1989 Japanese Standard	1998 Japanese Standard	Comments
<p>c. Applications of similarity [Note: Applications of similarity will include measurements of height and distance.]</p> <p>C. Quantitative relationships (1) Students will deepen their understanding of the representation of numbers, and learn to use that knowledge appropriately in real situations. [Note: Binary representation of numbers and representation of numbers as a series of on/off patterns will be covered] (2) Students will further deepen their understanding of functional relationships, understand the properties of linear equations, and expand their ability to use them.</p> <p>a. Understand that information about phenomenon can be obtained with linear equations</p> <p>b. Understand the properties of the ratio of change and graph of linear equations</p> <p>c. Learn to view linear equations with two variables as an expression of the functional relationship between the variables</p>	<p>C. Quantitative relationships</p> <p>(1) Students will understand linear functions by taking two quantities from a specific phenomenon and examining how they correspond, developing their ability to discover functional relationships, and to express and consider them.</p> <p>a. Students will learn that information about phenomenon can be obtained with linear equations.</p> <p>b. Students will learn to find the slope of the graph of a linear function and the features of such graphs, and how to use linear functions.</p> <p>c. Students will learn to view an equation in two variables as an expression that can be resolved as a function. [Note: The case where $x = h$ will not be covered.]</p>	<p>Section re-written (see above).</p> <p>Removed.</p> <p>“Specific (real-world) phenomenon” specified.</p> <p>No significant change.</p> <p>Clarification, and addition of “how to use linear functions”.</p> <p>Simplification of concept.</p>

1989 Japanese Standard	1998 Japanese Standard	Comments
	<p>(2) Students will understand probability through observation and experimentation of specific phenomena.</p> <p>a. Students will be able to systematically show sample spaces. [Note: Only simple cases such as those where the sample space can be shown as a tree diagram will be covered.]</p> <p>b. Students will understand probability as an expression of the likelihood of occurrence of an undetermined event, and learn to find the probability of simple events. [Note: Finding a probability as the complement of an event will not be covered.]</p>	<p>Added as replacement for statistics content.</p>

Appendix D: The 2004 Georgia Mathematics Performance Standards for Grades 6-8

Grade 6

By the end of grade six, students will understand the four arithmetic operations as they relate to positive rational numbers; convert between and compute with different forms of rational numbers; understand the concept of ratio and solve problems using proportional reasoning; understand and use line and rotational symmetry; determine the surface area and volume of solid figures; use variables to represent unknown quantities in formulae, algebraic expressions and equations; utilize data to make predictions; and determine the probability of a given event.

Instruction and assessment should include the use of manipulatives and appropriate technology. Topics should be represented in multiple ways including concrete/pictorial, verbal/written, numeric/data-based, graphical, and symbolic. Concepts should be introduced and used in the context of real world phenomena.

Concepts/Skills to Maintain

Operations with decimal fractions

Addition and subtraction of common fractions and mixed numbers with unlike denominators such as 2, 3, 4, 5, 6, 8, 10 and 12.

Modeling multiplication of common fractions

Modeling percent

Graphing data

Multiples and factors

Perimeter, capacity and area of geometric figures

Evaluating algebraic expressions

NUMBER AND OPERATIONS

Students will understand the meaning of the four arithmetic operations as related to positive rational numbers and will apply these concepts and associated skills in real world situations.

M6N1. Students will understand the meaning of the four arithmetic operations as related to positive rational numbers and will use these concepts to solve problems.

Apply factors and multiples.

Decompose numbers into their prime factorization (Fundamental Theorem of Arithmetic).

Determine the greatest common factor (GCF) and the least common multiple (LCM) for a set of numbers.

Add and subtract fractions and mixed numbers with unlike denominators.

Multiply and divide fractions and mixed numbers.

Use fractions, decimals, and percents interchangeably.

Solve problems involving fractions, decimals, and percents.

MEASUREMENT

Students will understand how to determine the volume and surface area of solid figures. They will understand and use the customary and metric systems of measurement to measure quantities efficiently and to represent volume and surface area appropriately.

M6M1. Students will convert from one unit to another within one system of measurement (customary or metric) by using proportional relationships.

M6M2. Students will use appropriate units of measure for finding length, perimeter, area and volume and will express each quantity using the appropriate unit.

- a. Measure length to the nearest half, fourth, eighth and sixteenth of an inch.
- b. Select and use units of appropriate size and type to measure length, perimeter, area and volume.
- c. Compare and contrast units of measure for perimeter, area, and volume.

M6M3. Students will determine the volume of fundamental solid figures (right rectangular prisms, cylinders, pyramids and cones).

- a. Determine the formula for finding the volume of fundamental solid figures.
- b. Compute the volumes of fundamental solid figures, using appropriate units of measure.
- c. Estimate the volumes of simple geometric solids.
- d. Solve application problems involving the volume of fundamental solid figures.

M6M4. Students will determine the surface area of solid figures (right rectangular prisms and cylinders).

- a. Find the surface area of right rectangular prisms and cylinders using manipulatives and constructing nets.
- b. Compute the surface area of right rectangular prisms and cylinders using formulae.
- c. Estimate the surface areas of simple geometric solids.
- d. Solve application problems involving surface area of right rectangular prisms and cylinders.

GEOMETRY

Students will further develop their understanding of plane and solid geometric figures, incorporating the use of appropriate technology and using this knowledge to solve authentic problems.

M6G1. Students will further develop their understanding of plane figures.

- a. Determine and use lines of symmetry.
- b. Investigate rotational symmetry, including degree of rotation.
- c. Use the concepts of ratio, proportion and scale factor to demonstrate the relationships between similar plane figures.
- d. Interpret and sketch simple scale drawings.
- e. Solve problems involving scale drawings.

M6G2. Students will further develop their understanding of solid figures.

- a. Compare and contrast right prisms and pyramids.
- b. Compare and contrast cylinders and cones.
- c. Interpret and sketch front, back, top, bottom and side views of solid figures.
- d. Construct nets for prisms, cylinders, pyramids, and cones.

ALGEBRA

Students will investigate relationships between two quantities. They will write and solve proportions and simple one-step equations that result from problem situations.

M6A1. Students will understand the concept of ratio and use it to represent quantitative relationships.

M6A2. Students will consider relationships between varying quantities.

- a. Analyze and describe patterns arising from mathematical rules, tables, and graphs.
- b. Use manipulatives or draw pictures to solve problems involving proportional relationships.
- c. Use proportions ($a/b=c/d$) to describe relationships and solve problems, including percent problems.
- d. Describe proportional relationships mathematically using $y = kx$, where k is the constant of proportionality.
- e. Graph proportional relationships in the form $y = kx$ and describe characteristics of the graphs.

- f. In a proportional relationship expressed as $y = kx$, solve for one quantity given values of the other two. Given quantities may be whole numbers, decimals, or fractions. Solve problems using the relationship $y = kx$.
- g. Use proportional reasoning ($a/b=c/d$ and $y = kx$) to solve problems.

M6A3. Students will evaluate algebraic expressions, including those with exponents, and solve simple one-step equations using each of the four basic operations.

DATA ANALYSIS AND PROBABILITY

Students will demonstrate understanding of data analysis by posing questions to be answered by collecting data. They will represent, investigate, and use data to answer those questions. Students will understand experimental and theoretical probability.

M6D1. Students will pose questions, collect data, represent and analyze the data, and interpret results.

- a. Formulate questions that can be answered by data. Students should collect data by using samples from a larger population (surveys), or by conducting experiments.
- b. Using data, construct frequency distributions, frequency tables, and graphs.
- c. Choose appropriate graphs to be consistent with the nature of the data (categorical or numerical). Graphs should include pictographs, histograms, bar graphs, line graphs, circle graphs, and line plots.
- d. Use tables and graphs to examine variation that occurs within a group and variation that occurs between groups.

- e. Relate the data analysis to the context of the questions posed.

M6D2. Students will use experimental and simple theoretical probability and understand the nature of sampling. They will also make predictions from investigations.

- a. Predict the probability of a given event through trials/simulations (experimental probability), and represent the probability as a ratio.
- b. Determine, and use a ratio to represent, the theoretical probability of a given event.
- c. Discover that experimental probability approaches theoretical probability when the number of trials is large.

Terms/Symbols: positive rational numbers, factors, multiples, decompose, prime numbers, prime factorization, Fundamental Theorem of Arithmetic, GCF, LCM, evaluate, surface area, metric system of measurement, customary system of measurement, proportional relationships, right rectangular prism, cylinder, pyramid, cone, geometric solid, net, geometric figures, line symmetry, rotational symmetry, similar plane figures, scale factor, scale drawings, relations, varying quantities, ratio, direct proportion, proportions, proportional reasoning, frequency distributions, pictographs, histograms, bar graphs, line graphs, circle graphs, line plot, frequency table, experimental probability, theoretical probability, sampling, event, random sample, population, non-routine word problems

Process Standards

Each topic studied in this course should be developed with careful thought toward helping every student achieve the following process standards.

M6P1. Using appropriate technology, students will solve problems that arise in mathematics and in other contexts.

- a. Build new mathematical knowledge through problem solving.
- b. Solve problems that arise in mathematics and in other contexts.
- c. Apply and adapt a variety of appropriate strategies to solve problems.
- d. Monitor and reflect on the process of mathematical problem solving.

M6P2. Students will investigate, develop, and evaluate mathematical arguments.

- a. Recognize reasoning and proof (evidence) as fundamental aspects of mathematics.
- b. Make and investigate mathematical conjectures.
- c. Develop and evaluate mathematical arguments and proofs.
- d. Select and use various types of reasoning and methods of proof.

M6P3. Students will use the language of mathematics to express ideas precisely.

- a. Organize and consolidate their mathematical thinking through communication.
- b. Communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
- c. Analyze and evaluate the mathematical thinking and strategies of others.
- d. Use the language of mathematics to express mathematical ideas precisely.

M6P4. Students will understand how mathematical ideas interconnect and build on one another. They will apply mathematics in other content areas.

- a. Recognize and use connections among mathematical ideas.
- b. Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
- c. Recognize and apply mathematics in contexts outside of mathematics.

M6P5. Students will create and use pictures, manipulatives, models and symbols to organize, record, and communicate mathematical ideas.

- a. Create and use representations to organize, record, and communicate mathematical ideas.
- b. Select, apply, and translate among mathematical representations to solve problems.
- c. Use representations to model and interpret physical, social, and mathematical phenomena.

Reading Standard Comment

After the elementary years, students are seriously engaged in reading for learning. This process sweeps across all disciplinary domains, extending even to the area of personal learning. Students encounter a variety of informational as well as fictional texts, and they experience text in all genres and modes of discourse. In the study of various disciplines of learning (language arts, mathematics, science, social studies), students must learn through reading the communities of discourse of each of those

disciplines. Each subject has its own specific vocabulary, and for students to excel in all subjects, they must learn the specific vocabulary of those subject areas in context.

Beginning with the middle grades years, students begin to self-select reading materials based on personal interests established through classroom learning. Students become curious about science, mathematics, history, and literature as they form contexts for those subjects related to their personal and classroom experiences. As students explore academic areas through reading, they develop favorite subjects and become confident in their verbal discourse about those subjects.

Reading across curriculum content develops both academic and personal interests in students. As students read, they develop both content and contextual vocabulary. They also build good habits for reading, researching, and learning. The Reading Across the Curriculum standard focuses on the academic and personal skills students acquire as they read in all areas of learning.

MCIR. Students will enhance reading in all curriculum areas by:

a. Reading in All Curriculum Areas

- Read a minimum of 25 grade-level appropriate books per year from a variety of subject disciplines and participate in discussions related to curricular learning in all areas
- Read both informational and fictional texts in a variety of genres and modes of discourse
- Read technical texts related to various subject areas

b. Discussing books

- Discuss messages and themes from books in all subject areas.
- Respond to a variety of texts in multiple modes of discourse.
- Relate messages and themes from one subject area to messages and themes in another area.
- Evaluate the merit of texts in every subject discipline.
- Examine author's purpose in writing.
- Recognize the features of disciplinary texts.

c. Building vocabulary knowledge

- Demonstrate an understanding of contextual vocabulary in various subjects.
- Use content vocabulary in writing and speaking.
- Explore understanding of new words found in subject area texts.

d. Establishing context

- Explore life experiences related to subject area content.
- Discuss in both writing and speaking how certain words are subject area related.
- Determine strategies for finding content and contextual meaning for unknown words.

Grade 7

By the end of grade seven, students are adept at manipulating rational numbers and equations and understand the general principles at work. Students will construct basic figures and examine the congruency of objects using transformations. They will examine properties of geometric shapes in space. They will describe and sketch plane and solid figures including cross-sections of various figures. Students will represent and describe a functional relation in a table, graph, and/or formula. They will also analyze the nature of changes and quantities in a linear relationship. Students will also understand and compute measure of variation and measures of central tendency. Students will discuss and understand the correspondence between data sets and their graphical representations.

Instruction and assessment should include the use of manipulatives and appropriate technology. Topics should be represented in multiple ways including concrete/pictorial, verbal/written, numeric/data-based, graphical, and symbolic. Concepts should be introduced and used in the context of real world phenomena.

Concepts/Skills to Maintain

Operations with fractions including mixed numbers

Multiplication & division of positive rational numbers

Surface area & volume

Circumference of circle

M7N. Number and Operations

Students will further develop their understanding of the concept of rational numbers and apply them to real world situations.

M7N1. Students will understand the meaning of positive and negative numbers including rational numbers and will compute with them.

- a. Find the absolute value of a number and understand it as the distance from the origin on a number line.
- b. Compare and order rational numbers including repeating decimals.
- c. Add, subtract, multiply and divide positive and negative rational numbers.
- d. Solve problems using rational numbers.

M7G. Geometry

Students will further develop and apply their understanding of plane and solid geometrical figures.

M7G1. Students will construct plane figures that meet given conditions. They will also demonstrate understanding of transformations.

- a. Make basic constructions using a compass and straight edge.
- b. Demonstrate understanding of translations, symmetry, dilations, rotations and reflections.
- c. Given a figure in the coordinate plane, determine the coordinates resulting from a translation, dilation or reflection.

M7G2. Students will consider geometrical figures through various manipulations to deepen understanding of figures in space.

- a. Describe solid geometric figures formed by movement of plane figures through space.
- b. Sketch/model and describe various cross sections of cones, cylinders, pyramids and prisms.

REMARK: M7G1a. Constructions should include copying a segment and angle, the bisector of an angle, the perpendicular bisector of a line segment, congruent line segments, congruent angles, parallel lines, and circles.

M7A. Algebra

Students will demonstrate an understanding of linear relations and fundamental algebraic concepts.

M7A1. Students will represent and evaluate quantities using algebraic expressions.

- a. Translate verbal phrases to algebraic expressions.
- b. Use and evaluate algebraic expressions.
- c. Add and subtract linear expressions.
- d. Apply the properties of numbers to evaluate expressions (commutative, associative, and distributive properties).

M7A2. Students will understand and apply linear equations with one variable.

- a. Interpret the meaning of variables and the solution of an equation.

- b. Understand the properties of equality.
- c. Solve problems by applying simple linear equations.
- d. Solve two-step linear equations with one variable.

M7A3. Students will understand relations and functions.

- a. Graph coordinates in a plane.
- b. Represent, describe and analyze a functional relation from a table, graph, and/or formula.
- c. Describe the variation of two quantities.
- d. Understand and graph direct proportions.
- e. Understand and graph inverse proportions.

REMARK: M7A2. Algebra in seventh grade should emphasize linear relationships.

REMARK: M7A3. Emphasize how change in one variable affects the other variable (corresponding variable quantities).

M7D. Data Analysis and Probability

Students will further develop and demonstrate their understanding of functional and statistical relationships by analyzing tables and graphs and develop their abilities to represent and use them.

M7D1. Students will collect, organize, display, and analyze data by using tables and graphs and by determining the tendencies of the data considering

representative values and dispersion.

- a. Collect and organize data.
- b. Summarize data by constructing its frequency distribution table.
- c. Analyze data with respect to measure of variation (range) and measures of central tendency (mean, median, and mode), including outliers.
- d. Display data in appropriate graphs.
- e. Analyze and draw conclusions about the data.

REMARK: M7D1. Students should collect data through surveys.

REMARK: M7D1d. Graphs should include histograms, line plots, stem-and-leaf plots, scatter plots and box-and-whisker plots.

M7P. Process Skills

Students will apply mathematical concepts and skills in the context of authentic problems and will understand concepts rather than merely following the sequence of procedures. The student will use the process standards as a way acquiring and using content knowledge.

M7P1. Using appropriate technology the student will solve problems that arise in mathematics and in other context.

- a. Solve non-routine word problems using strategies learned in previous grades.
- b. Solves single and multi-step routine word problems related to all appropriate seventh grade math standards.

- c. Determine the operation(s) needed to solve a problem.
- d. Determine the most efficient way to solve a problem (mentally, paper/pencil, or calculator).

M7P2. Students will investigate, develop, and evaluate mathematical arguments.

M7P3. Students will use the language of mathematics to express ideas precisely.

M7P4. Students understand how mathematical ideas interconnect and build on one another and apply mathematics in other content areas.

M7P5. Students will create and use pictures, manipulatives, models and symbols to organize, record, and communicate mathematical ideas.

Terms/Symbols:

natural number, sign, integers, opposite, negative, positive, absolute value, term, coefficient, prime number, prime factors, greatest common divisor (GCF), least common divisor (LCM), reciprocal, exponents, variables, commutative property, associative property, distributive property, algebraic expressions, linear equations, direct and indirect proportions, function, variation, mean, median, mode, range, histogram, frequency, frequency distribution, scatter plot, line plot, box-and-whisker plot, stem-and-leaf plot, $<$, $>$, \leq , \geq , π , $//$, \perp , \angle , Δ , angles, circles, chord, interior angle, arc, circumference, perimeter, projection, polyhedra, coordinate plane, pyramids, cones,

cylinders, translations, symmetry, rotation, reflection, bisectors, parallel lines,
perpendicular lines, cross-sections

Grade 8

By the end of grade eight, students will represent and analyze numeration systems and mathematical situations using algebraic symbols. They will develop a conceptual understanding of different uses of variables and they will use symbolic algebra to represent situations to solve problems, especially those that involve linear relationships.

Students will recognize and generate equivalent forms for simple algebraic expressions and solve linear equations. They will also understand the meaning of inequality and how to apply linear inequalities. Students will use properties of fundamental figures in a plane. They will create and critique inductive and deductive arguments concerning geometric ideas, such as perpendicularity, parallelism, congruence, similarity, line, angle, and other polygonal relationships including the Pythagorean Theorem. Students will also identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations. Students will analyze and interpret rates of change in various contexts such as graphical and numerical data and they will solve problems involving direct and inverse variation. They will explore relationships between symbolic expressions and graphs of lines, paying particular attention to the meaning of intercept and slope.

Instruction and assessment should include the use of manipulatives and appropriate technology. Topics should be represented in multiple ways including concrete/pictorial, verbal/written, numeric/data-based, graphical, and symbolic. Concepts should be introduced and used in the context of real world phenomena.

Concepts/Skills to Maintain

Operations with rational numbers

Properties of equalities

Direct & inverse proportions

Solving multi-step equations

Properties of real numbers

Statistics

M8N. Number and Operations

Students will understand concepts of large and small numbers and apply them to real world situations.

M8N1. Students will understand different representations of numbers using square root, exponential, and scientific notation.

- a. Apply the laws of exponents to simplify expressions containing integral powers.
- b. Use scientific notation to represent numbers.
- c. Find the square root of a number.
- d. Use a calculator to solve problems involving square roots, exponents, and scientific notation.

REMARK: M8N. Distinguish between scientific notation on paper and the way it might be presented on the calculator.

REMARK: M8N1a. Transfer these concepts to the algebraic law of exponents.

M8A. Algebra

Students will analyze and interpret linear equations, inequalities, and functions. Students will evaluate and use algebraic expressions. They will solve equations, understand linear equations and inequalities, and solve systems of linear equations. Students will understand linear functions and proportionality, direct and inverse variations, and they will apply these skills to real world situations.

M8A1. Students will represent, solve, and analyze mathematical situations algebraically.

- a. Simplify and evaluate algebraic expressions.
- b. Translate word phrases to algebraic expressions and equations.
- c. Solve algebraic equations.

M8A2. Students will understand linear relations and functions.

- a. Identify relations and functions as linear or nonlinear.
- b. Translate among verbal, tabular, graphic, and algebraic representations of functions.

M8A3. Students will graph and analyze graphs of linear equations.

- a. Estimate and determine a line of best fit from a scatter plot.
- b. Graph equations of the form $y = mx + b$.
- c. Graph equations of the form $Ax + By = C$.
- d. Determine the equation of a line given a graph or data.

- e. Interpret the meaning of the slope and y -intercept in a given situation.
- f. Solve problems involving inverse and direct proportions (variations) and identify the constant of proportionality.

M8A4. Students will understand the meaning of systems of linear equations and use them to solve problems.

- a. Understand the meaning of systems of linear equations.
- b. Solve systems of equations algebraically and graphically.
- c. Solve word problems using systems of equations and interpret their solutions.

M8A5. Students will understand the meaning of and graph linear inequalities.

- a. Solve and graph linear inequalities and explain the solution.
- b. Use the properties of inequality.
- c. Graph linear inequalities.

M8A6. Students will use and simplify monomials and polynomials.

- a. Identify monomials and polynomials.
- b. Add and subtract simple monomials and polynomials.
- c. Multiply and divide simple monomials.

REMARK: M8A3e. Concept of slope should include an introduction to the idea of constant rate of change.

REMARK: M8A3f. A connection should be made between the ideas of scale factor and constant of proportionality.

M8G. Geometry

Students will use and apply geometric properties of plane figures. They will understand and critique inductive and deductive arguments concerning geometric ideas and relationships including congruence, similarity, and the Pythagorean Theorem.

M8G1. Students will analyze and use characteristics and properties of geometric figures.

- a. Use the properties of parallel and perpendicular lines.
- b. Use and apply properties of angle pairs such as complementary, supplementary and vertical angles.
- c. Use and apply the properties of triangles and parallelograms.
- d. Apply properties of the right triangle and the Pythagorean Theorem.

M8G2. Students will use the properties of similarity and congruency and apply these concepts to geometric figures.

- a. Understand the meaning of similarity and the conditions for similarity of geometric figures.
- b. Understand the properties of the ratio of segments of parallel lines cut by one or more transversals.
- c. Understand the meaning of congruency and the conditions for congruent triangles and other polygons.

- d. Use properties to determine similarity and congruency of triangles.

REMARK: M8G2c. Measurement of height and distance as applications of similarity should be taught.

M8. Data Analysis and Probability

Students will use and understand set theory and simple counting techniques.

Students will determine the theoretical probability of simple events.

M8D1. Students will apply basic concepts of set theory.

- a. Demonstrate relationships among sets through use of Venn Diagrams.
- b. Determine subsets, complements, intersection and union of sets.
- c. Use set notation to denote elements of a set.

M8D2. Students will determine the number of outcomes related to a given event.

- a. Use tree diagrams to find the number of outcomes.
- b. Apply addition and multiplication counting principles.

M8D3. Students will use the basic laws of probability.

- a. Find the probability of simple, independent events.
- b. Find the probability of compound, independent events.

M8. Process Skills

Students will apply mathematical concepts and skills in the context of authentic problems and will understand concepts rather than merely following the sequence of procedures. They will also use the process standards as a way acquiring and using content knowledge.

M8P1. Using appropriate technology the student will solve problems that arise in mathematics and in other context.

- a. Solve non-routine word problems using strategies learned in previous grades.
- b. Solves single and multi-step routine word problems related to all appropriate eighth grade math standards.
- c. Determine the operation(s) needed to solve a problem.
- d. Determine the most efficient way to solve a problem (mentally, paper/pencil, or calculator).

M8P2. Students will investigate, develop, and evaluate mathematical arguments.

M8P3. Students will use the language of mathematics to express ideas precisely.

M8P4. Students understand how mathematical ideas interconnect and build on one another and apply mathematics in other content areas.

M8P5. Students will create and use pictures, manipulatives, models and symbols to organize, record, and communicate mathematical ideas.

Terms/Symbols:

\approx , \cong , $<$, $>$, \geq , \leq , $=$, open sentence, substitute, solution, additive inverse, multiplicative inverse, exponential form, equation, numeration systems, scientific notation, significant digits, inequality, linear equation, linear inequality, like terms, unlike terms, algebraic expression, variable, monomial, binomial, trinomial, polynomial, exponent, power, degree of a monomial, degree of a polynomial, descending order, ascending order, simplify, evaluate, systems of linear equations

\equiv , ∞ , \approx , $||$, \perp , point, line, plane, line segment, endpoints, intersection, union, ray, angle, degree, opposite angle, vertical angles, interior angle, exterior angle, complementary, supplementary, parallel lines, perpendicular lines, sides, regular polygon, triangle, quadrilateral, parallelogram, proof, similar, similarity, rate, scale drawings, ratio, proportion, corresponding sides, corresponding angles, congruent, diagonal, Pythagorean Theorem, and arguments.

function, relation, domain, range, directly proportional, constant function, constant of proportionality ($y = kx$), vertical line test, direct variation, inverse variation, inversely proportional, rate of change, slope, intercept, coordinate plane

Appendix E: A Comparison of the 1989 Japanese and 2004

Georgia Mathematics Curricula for Grades 6-8

Grade 6

The following is a direct comparison showing differences between the 1989 Japanese Guidelines for Learning and Instruction for 6th grade math and Georgia's 2004 adaptation of those standards.

1989 Japanese Standard	2004 Georgia Standard	Comments
1. Goals (1) To understand fraction multiplication and division, to learn how to use those operations, and to deepen students' understanding of multiplication and division. (2) To teach students how to find the volume of basic geometric figures. To teach students about systems of measurement, and how to perform measurements efficiently.	Students will understand the meaning of the four arithmetic operations as related to positive rational numbers and will apply these concepts and associated skills in real world situations. Students will understand how to determine the volume and surface area of solid figures. They will understand and use the customary and metric systems of measurement to measure quantities efficiently and to represent volume and surface area appropriately.	Under both the 1989 Japanese standards and the 2004 Georgia standards, addition and subtraction of fractions with same denominators is covered in the 4th grade, and of fractions with differing denominators in the 5th grade. Surface area is not covered in the Japanese standards. Needless to say, the imperial system of measures is not studied in Japan.

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>(3) To deepen students' understanding of geometric shapes by focusing on symmetry.</p> <p>(4) To extend the idea of functions through understanding of proportions, and to use that concept effectively to consider quantitative relationships. To learn to make statistical observations and expressions through observation of data distributions, etc.</p>	<p>Students will further develop their understanding of plane and solid geometric figures, incorporating the use of appropriate technology and using this knowledge to solve authentic problems.</p> <p>Students will investigate relationships between two quantities. They will write and solve proportions and simple one-step equations that result from problem situations.</p> <p>Students will demonstrate understanding of data analysis by posing questions to be answered by collecting data. They will represent, investigate, and use data to answer those questions.</p> <p>Students will understand experimental and theoretical probability.</p>	<p>Addition of technology requirement, and prescription of "authentic problems".</p> <p>The Georgia standards do not retain the notion of "function" (function terminology was also removed in the 1998 Japanese standards). The Georgia standards seem to emphasize data <i>collection</i>, while the Japanese standards emphasize observation of features of data, such as distribution. Georgia standards add "experimental and theoretical probability", whereas the 1989 Japanese standards introduce probability in the 8th grade.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>2. Content A. Numbers and expressions (1) Students will understand the meaning of multiplication and division of rational numbers, extend their abilities to perform these functions, and deepen their understanding of multiplication and division. [Note: Insure that students understand that relationships shown by equations, etc., are also valid when fractions are used.] a. Students will grasp the meaning of multiplication and division, both when the numbers involved are integers and when they are rational numbers. b. Students will learn the method of calculation of multiplication and division problems involving rational numbers. c. Students will understand division as multiplication by reciprocals of fractions. d. Students will be able to re-write multiplication and division of integer and decimal numbers as problems involving fractions. Also, they will learn to represent multiplication and division problems as a single fraction.</p> <p>B. Quantities and measurements [Note: Lessons for this</p>	<p>Number and operations</p> <p>M6N1. Students will understand the meaning of the four arithmetic operations as related to positive rational numbers and will use these concepts to solve problems. Apply factors and multiples. Decompose numbers into their prime factorization (Fundamental Theorem of Arithmetic). Determine the greatest common factor (GCF) and the least common multiple (LCM) for a set of numbers. Add and subtract fractions and mixed numbers with unlike denominators. Multiply and divide fractions and mixed numbers. Use fractions, decimals, and percents interchangeably. Solve problems involving fractions, decimals, and percents.</p> <p>Measurement</p>	<p>The Georgia standard includes a large number of topics that are not mentioned in the Japanese standards – factors, multiples, decomposition to primes, GCF, LCM, and decimal and percent arithmetic (decimal arithmetic is covered in 5th grade under the 1989 Japanese standards, and not reviewed in 6th grade), and conversion between fraction, decimal, and percent forms of numbers. It is interesting to note that finding the GCF and LCM for a group of numbers is one of the topics listed for the Georgia standards, while this is specifically proscribed by the Commentary to the Japanese standards [MEXT 2003].</p> <p>Introduction of letter variables not recommended in Georgia standards.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>section should make efforts to use letter variables such as a, x, etc. so as to allow students to become used to them.]</p> <p>(1) Students will learn to find the volume and other properties of basic solid objects through experimentation, direct measurement, etc.</p> <p>a. Students will learn how to find the volume and surface area of basic prisms and cylinders.</p> <p>b. Students will learn how to find the volume of basic pyramid and cone solids, and in simple cases to find their surface areas. [Note: The solids used should be simple enough so that an exploded diagram of the shapes can be easily drawn. The cones for which surface area is found should be simple ones with exploded side shapes that are half circles, quarter circles, etc.]</p>	<p>M6M3. Students will determine the volume of fundamental solid figures (right rectangular prisms, cylinders, pyramids and cones).</p> <p>Determine the formula for finding the volume of fundamental solid figures. Compute the volumes of fundamental solid figures, using appropriate units of measure.</p> <p>Estimate the volumes of simple geometric solids. Solve application problems involving the volume of fundamental solid figures.</p> <p>M6M4. Students will determine the surface area of solid figures (right rectangular prisms and cylinders).</p> <p>Find the surface area of right rectangular prisms and cylinders using manipulatives and constructing nets. Compute the surface area of right rectangular prisms and cylinders using formulae. Estimate the surface areas of simple geometric solids. Solve application problems involving surface area of right rectangular prisms and cylinders.</p>	<p>Estimation skills added in Georgia standards.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>(2) Students will deepen their understanding of performing measurements and units, and improve their abilities to make measurements.</p> <p>a. Students will make efficient measurements using proportional measurements, etc.</p> <p>b. Students will understand the metric system and its system of units, and use it effectively to make measurements. [Note: The units kiloliter (kl), milligram (mg), and ton (t) should also be briefly mentioned.]</p>	<p>M6M1. Students will convert from one unit to another within one system of measurement (customary or metric) by using proportional relationships.</p> <p>M6M2. Students will use appropriate units of measure for finding length, perimeter, area and volume and will express each quantity using the appropriate unit. Measure length to the nearest half, fourth, eighth and sixteenth of an inch. Select and use units of appropriate size and type to measure length, perimeter, area and volume. Compare and contrast units of measure for perimeter, area, and volume.</p>	<p>Needless to say, conversion between metric and imperial system units is not covered in Japan. Similarly, due to the use of sufficiently small units of measure in the metric system (grams, millimeters, etc.) and that system's unit structure, measurement to fractional units is generally not required and decimal numbers are used instead.</p>
<p>C. Figures</p> <p>(1) Students will further deepen their understanding of plane figures.</p> <p>a. Students will understand the meaning of point and line symmetries, and consider the symmetries of basic geometric figures.</p> <p>b. Students will round out their understanding of the shape and size of figures, learning to recognize and draw simple rescalings of figures.</p>	<p>Geometry</p> <p>M6G1. Students will further develop their understanding of plane figures. Determine and use lines of symmetry. Investigate rotational symmetry, including degree of rotation. Use the concepts of ratio, proportion and scale factor to demonstrate the relationships between similar plane figures. Interpret and sketch simple scale drawings. Solve problems involving scale drawings.</p>	<p>The Georgia standard adds a requirement for "problems involving scale drawings", while the Japanese standards only require that students be able to recognize and draw scaled figures.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>(2) Students will deepen their understanding of basic solid figures through manipulations such as construction and decomposition. [Note: Students should learn to read and create appropriate sketches and exploded diagrams, and in simple cases how to read and create 2- and 3-dimensional diagrams.]</p> <p>a. Students will learn about basic prisms and cylinders.</p> <p>b. Students will learn about basic pyramids and cones.</p>	<p>M6G2. Students will further develop their understanding of solid figures.</p> <p>Compare and contrast right prisms and pyramids.</p> <p>Compare and contrast cylinders and cones.</p> <p>Interpret and sketch front, back, top, bottom and side views of solid figures.</p> <p>Construct nets for prisms, cylinders, pyramids, and cones.</p>	<p>No significant change.</p>
<p>D. Quantitative relationships</p> <p>[Note: Lessons for this section should make efforts to use letter variables such as a, x, etc. so as to allow students to become used to them.]</p>	<p>Algebra</p>	
<p>(1) Students will learn the meaning of ratios and how to use them.</p>	<p>M6A1. Students will understand the concept of ratio and use it to represent quantitative relationships.</p>	<p>No significant change.</p>
<p>(2) Students will improve their abilities to observe the relationship between two mutually changing quantities.</p> <p>a. Students will understand the meaning of proportion. Students will also learn to use mathematical expressions and graphs to examine the features of such relationships. [Note: Graphs of proportional relationships should be constructed so as to</p>	<p>M6A2. Students will consider relationships between varying quantities. Analyze and describe patterns arising from mathematical rules, tables, and graphs.</p> <p>Use manipulatives or draw pictures to solve problems involving proportional relationships.</p> <p>Use proportions ($a/b=c/d$) to describe relationships and solve problems, including percent problems.</p>	<p>Constant of proportionality added in Georgia standards, along with finding solutions of an equation of proportionality for an arbitrary element. Note that the Japanese standards specifically call for simple usages of inverse proportions, whereas the Georgia standards are quite advanced. The Japanese standards specify that range of relationships should be noted, as</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>gradually call attention to the continuous change between the quantities and the range under which the change occurs.] b. Students will understand the meaning of inverse proportion. Students will also learn to use mathematical expressions to represent simple examples. [Note: Graphs of inverse proportions should be only complex enough so that a broken-line graph can show the change between the two quantities in question.]</p>	<p>Describe proportional relationships mathematically using $y = kx$, where k is the constant of proportionality. Graph proportional relationships in the form $y = kx$ and describe characteristics of the graphs. In a proportional relationship expressed as $y = kx$, solve for one quantity given values of the other two. Given quantities may be whole numbers, decimals, or fractions. Solve problems using the relationship $y = kx$. Use proportional reasoning ($a/b=c/d$ and $y = kx$) to solve problems. M6A3. Students will evaluate algebraic expressions, including those with exponents, and solve simple one-step equations using each of the four basic operations.</p>	<p>negative values are often not applicable to real-world proportional and inversely proportional relationships.</p> <p>Not in the Japanese standards.</p>
<p>(3) Students will learn to examine simple examples of data scatter, and how to examine and represent it statistically. a. Students will learn about tables and graphs that show frequency distributions. b. Students will learn that proportions of a sample of data can give information about the tendencies of the</p>	<p>Data Analysis and Probability M6D1. Students will pose questions, collect data, represent and analyze the data, and interpret results. Formulate questions that can be answered by data. Students should collect data by using samples from a larger population (surveys), or by conducting experiments. Using data, construct frequency distributions,</p>	<p>Data collection element added. Study of variation within a group and between groups added in the Georgia standards. Ordering of the set of possible outcomes of a probabilistic event removed. (3).b removed. (4) removed.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>entire body of data. c. Students will learn to select and adapt the table or graph that is most appropriate to their goals.</p> <p>(4) Students should gradually be taught that for simple matters possible outcomes may be ordered and examined.</p>	<p>frequency tables, and graphs. Choose appropriate graphs to be consistent with the nature of the data (categorical or numerical). Graphs should include pictographs, histograms, bar graphs, line graphs, circle graphs, and line plots. Use tables and graphs to examine variation that occurs within a group and variation that occurs between groups. Relate the data analysis to the context of the questions posed. M6D2. Students will use experimental and simple theoretical probability and understand the nature of sampling. They will also make predictions from investigations. Predict the probability of a given event through trials/simulations (experimental probability), and represent the probability as a ratio. Determine, and use a ratio to represent, the theoretical probability of a given event. Discover that experimental probability approaches theoretical probability when the number of trials is large.</p>	<p>Added.</p>

Grade 7

The following is a direct comparison showing differences between the 1989 Japanese Guidelines for Learning and Instruction for 7th grade math and Georgia's 2004 adaptation of those standards.

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>A. Numbers and expressions (1) Students will understand positive and negative numbers, and learn how to use the four basic arithmetic operations with them. [Note: Reasoning for the possibility of performing the four arithmetic operations should be discussed.]</p> <p>(2) Students will develop their ability to express relationships and laws by using letter variables in mathematical expressions, and learn how to perform calculations using simple equations.</p> <p>a. Students will use letter variables.</p> <p>b. Students will learn how multiplication and division are represented in expressions that include</p>	<p>Numbers and operations M7N1. Students will understand the meaning of positive and negative numbers including rational numbers and will compute with them.</p> <p>Find the absolute value of a number and understand it as the distance from the origin on a number line.</p> <p>Compare and order rational numbers including repeating decimals.</p> <p>Add, subtract, multiply and divide positive and negative rational numbers.</p> <p>Solve problems using rational numbers.</p> <p>M7A1. Students will represent and evaluate quantities using algebraic expressions.</p> <p>Translate verbal phrases to algebraic expressions.</p> <p>Use and evaluate algebraic expressions.</p> <p>Add and subtract linear expressions.</p> <p>Apply the properties of numbers to evaluate expressions (commutative, associative, and distributive</p>	<p>Absolute value and distance from origin concepts added in Georgia standards. Repeating decimals added. Review of rational numbers added.</p> <p>This section was moved to the "Algebra" strand in the Georgia standards. "Translate verbal phrases" section added. Use of commutative, associative, and distributive properties added.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>letter variables. c. Students will learn how to add and subtract linear equations. [Note: Discussion should only be of depth required to solve calculations involving single-variable linear equations]</p> <p>(3) Students will understand the meaning of equations, and learn how to use single-variable linear equations.</p> <p>a. The meaning of letter variables found in an equation, and their solution.</p> <p>b. The properties of equality.</p> <p>c. The solution to single-variable linear equations</p>	<p>properties).</p> <p>M7A1. Students will represent and evaluate quantities using algebraic expressions. Translate verbal phrases to algebraic expressions. Use and evaluate algebraic expressions. Add and subtract linear expressions. Apply the properties of numbers to evaluate expressions (commutative, associative, and distributive properties).</p> <p>M7A2. Students will understand and apply linear equations with one variable. Interpret the meaning of variables and the solution of an equation. Understand the properties of equality. Solve problems by applying simple linear equations. Solve two-step linear equations with one variable.</p>	<p>No significant change.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>B. Figures</p> <p>(1) Students will improve their ability to use foresight in constructing basic geometric shapes, and deepen their understanding of plane figures.</p> <p>a. Fundamentals of figure construction such as angle bisectors, perpendicular bisectors of line segments, perpendicular lines, etc.</p> <p>b. Parallel translation, symmetric translation, and rotational translation</p> <p>c. The view of geometric figures as a collection of points that meet a certain requirement, and the creation of figures that meet given requirements</p> <p>(2) Students will consider geometric figures by performing various operations on them, deepening their understanding of spatial figures.</p> <p>a. Positional relationships of lines and planes in space</p> <p>b. The creation of spatial figures by movement of plane figures in space</p> <p>c. Cross sections, projections, and explosions of spatial figures [Note: Discussion of technical aspects and applications of cross-sections and projections</p>	<p>Geometry</p> <p>M7G1. Students will construct plane figures that meet given conditions. They will also demonstrate understanding of transformations.</p> <p>Make basic constructions using a compass and straight edge.</p> <p>Demonstrate understanding of translations, symmetry, dilations, rotations and reflections.</p> <p>Given a figure in the coordinate plane, determine the coordinates resulting from a translation, dilation or reflection.</p> <p>M7G2. Students will consider geometrical figures through various manipulations to deepen understanding of figures in space.</p> <p>Describe solid geometric figures formed by movement of plane figures through space.</p> <p>Sketch/model and describe various cross sections of cones, cylinders, pyramids and prisms.</p> <p>REMARK: M7G1a. Constructions should include copying a segment and angle, the bisector of an angle, the perpendicular bisector of a line segment,</p>	<p>Japanese curriculum does not cover new coordinates resulting from a transformation (coordinates are first fully studied in Mathematics II, generally taught in 11th grade). View of geometric figures as a set of points removed.</p> <p>No significant change.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>should not be delved into deeply.]</p> <p>C. Quantitative relationships</p> <p>(1) Students will discover quantitative measures that change together in some event, consider and elucidate the relationship between those measures, and understand that relationship as a mathematical function.</p> <ul style="list-style-type: none"> a. Changes and correspondences b. The meaning of axis coordinates c. Display of a mathematical function in a table, graph, or diagram <p>(2) Students will deepen their understanding of the equations and graphs of pro-portions and inverse proportions, and increase their ability to consider and express quantitative relationships. [Note: Discussion should include the construction of accurate graphs.]</p>	<p>congruent line segments, congruent angles, parallel lines, and circles.</p> <p>Algebra</p> <p>M7A3. Students will understand relations and functions.</p> <p>Graph coordinates in a plane.</p> <p>Represent, describe and analyze a functional relation from a table, graph, and/or formula.</p> <p>Describe the variation of two quantities.</p> <p>Understand and graph direct proportions.</p> <p>Understand and graph inverse proportions.</p> <p>REMARK: M7A2. Algebra in seventh grade should emphasize linear relationships.</p> <p>REMARK: M7A3. Emphasize how change in one variable affects the other variable (corresponding variable quantities).</p> <p>Data Analysis and Probability</p> <p>M7D1. Students will collect, organize, display, and analyze data by using tables and graphs and by determining the tendencies</p>	<p>“Meaning of axis coordinates” dropped, though one can assume that out of necessity the concept will be covered. Remarks added to Georgia standards, though these remarks remain within the spirit of the 1989 Japanese standards.</p> <p>No data analysis/probability content for 7th grade under the 1989 Japanese standards.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
	<p>of the data considering representative values and dispersion.</p> <p>Collect and organize data.</p> <p>Summarize data by constructing its frequency distribution table.</p> <p>Analyze data with respect to measure of variation (range) and measures of central tendency (mean, median, and mode), including outliers.</p> <p>Display data in appropriate graphs.</p> <p>Analyze and draw conclusions about the data.</p> <p>REMARK: M7D1. Students should collect data through surveys.</p> <p>REMARK: M7D1d. Graphs should include histograms, line plots, stem-and-leaf plots, scatter plots and box-and-whisker plots.</p>	

Grade 8

The following is a direct comparison showing differences between the 1989 Japanese Guidelines for Learning and Instruction for 8th grade math and Georgia's 2004 adaptation of those standards.

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>Numbers and expressions</p> <p>(1) Students will learn to perform the four basic arithmetic operations on expressions that include letter variables.</p> <p>a. Addition and subtraction of simple expressions</p> <p>b. Multiplication and division of monomial expressions</p> <p>(2) Students will further develop their abilities to discover quantitative relationships within phenomena, and use letter variables within equations to express those relationships.</p> <p>a. The use of equations</p> <p>b. Simple modifications of inequalities</p>	<p>Number and operations</p> <p>M8A1. Students will represent, solve, and analyze mathematical situations algebraically. Simplify and evaluate algebraic expressions. Translate word phrases to algebraic expressions and equations. Solve algebraic equations.</p> <p>M8A2. Students will understand linear relations and functions. Identify relations and functions as linear or nonlinear. Translate among verbal, tabular, graphic, and algebraic representations of functions.</p> <p>M8A3. Students will graph and analyze graphs of linear equations. Estimate and determine a line of best fit from a scatter plot. Graph equations of the form $y = mx + b$. Graph equations of the form $Ax + By = C$.</p>	<p>Complete re-write for the Georgia standards here and in other areas below, apparently to bring much of the previous algebra course to 8th grade. Everything from the 1989 Japanese standard is retained, but much more is added.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>(3) Students will understand the meaning of inequalities, and learn to use single-variable linear inequalities. [Note: Here and in other areas, the process of calculation will be shown in a flow diagram.]</p> <ul style="list-style-type: none"> a. The meaning of inequalities and their solutions b. The properties of inequalities c. Solving single-variable linear inequalities <p>(4) Students will understand the meaning of simultaneous systems of equations and their solutions, and learn how to use them.</p> <ul style="list-style-type: none"> a. The meaning of linear equations in two-variables and their solutions b. How to solve simple systems of simultaneous 	<p>Determine the equation of a line given a graph or data. Interpret the meaning of the slope and y-intercept in a given situation. Solve problems involving inverse and direct proportions (variations) and identify the constant of proportionality. M8A6. Students will use and simplify monomials and polynomials. Identify monomials and polynomials. Add and subtract simple monomials and polynomials. Multiply and divide simple monomials.</p> <p>M8A5. Students will understand the meaning of and graph linear inequalities. Solve and graph linear inequalities and explain the solution. Use the properties of inequality. Graph linear inequalities.</p> <p>M8A4. Students will understand the meaning of systems of linear equations and use them to solve problems. Understand the meaning of systems of linear equations. Solve systems of equations algebraically and graphically. Solve word problems</p>	<p>Graphing of inequalities added.</p> <p>Graphical solutions to systems of equations added. Word problems added.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>linear equations [Note: Systems of two equations in two variables will be covered.]</p>	<p>using systems of equations and interpret their solutions.</p> <p>M8N1. Students will understand different representations of numbers using square root, exponential, and scientific notation.</p> <p>Apply the laws of exponents to simplify expressions containing integral powers.</p> <p>Use scientific notation to represent numbers.</p> <p>Find the square root of a number.</p> <p>Use a calculator to solve problems involving square roots, exponents, and scientific notation.</p> <p>REMARK: M8N. Distinguish between scientific notation on paper and the way it might be presented on the calculator.</p> <p>REMARK: M8N1a. Transfer these concepts to the algebraic law of exponents.</p> <p>REMARK: M8A3e. Concept of slope should include an introduction to the idea of constant rate of change.</p> <p>REMARK: M8A3f. A connection should be made between the ideas of scale factor and constant of proportionality.</p>	<p>Added. Square root taught in 9th grade under the 1989 Japanese standards.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>B. Figures</p> <p>(1) Based upon the properties of parallel lines and triangle congruencies, students will learn how to discover the properties of plane figures and prove them.</p> <p>a. The properties of parallel lines</p> <p>b. The requirements for congruency of triangles</p> <p>c. The properties of triangles and parallelograms</p> <p>(2) The concept of similarity of triangles will be made clear, and based on the requirements for triangle similarity and congruency students will develop their skills in discovering and proving the properties of plane shapes.</p> <p>a. The meaning of similarity and the conditions for triangle similarity.</p> <p>b. The properties of parallel lines and the ratios of line segments.</p> <p>c. Applications of similarity [Note: Applications of similarity will include measurements of height and distance.]</p>	<p>Geometry</p> <p>M8G1. Students will analyze and use characteristics and properties of geometric figures.</p> <p>Use the properties of parallel and perpendicular lines.</p> <p>Use and apply properties of angle pairs such as complementary, supplementary and vertical angles.</p> <p>Use and apply the properties of triangles and parallelograms.</p> <p>Apply properties of the right triangle and the Pythagorean Theorem.</p> <p>M8G2. Students will use the properties of similarity and congruency and apply these concepts to geometric figures.</p> <p>Understand the meaning of similarity and the conditions for similarity of geometric figures.</p> <p>Understand the properties of the ratio of segments of parallel lines cut by one or more transversals.</p> <p>Understand the meaning of congruency and the conditions for congruent triangles and other polygons.</p> <p>Use properties to determine similarity and congruency of triangles.</p> <p>REMARK: M8G2c. Measurement of height and distance as applications of similarity should be taught.</p>	<p>Study of perpendicular lines added. Angle pairs added. Pythagorean Theorem added. Right triangles and their properties including the Pythagorean Theorem are studied in the 9th grade under the 1989 Japanese standards.</p> <p>Ratio of segments of parallel lines cut by transversals added. Measurement of height and distance added.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
<p>C. Quantitative relationships</p> <p>(1) Students will deepen their understanding of the representation of numbers, and learn to use that knowledge appropriately in real situations. [Note: Binary representation of numbers and representation of numbers as a series of on/off patterns will be covered]</p> <p>(2) Students will further deepen their understanding of functional relationships, understand the properties of linear equations, and expand their ability to use them.</p> <p>a. Understand that information about phenomenon can be obtained with linear equations</p> <p>b. Understand the properties of the ratio of change and graph of linear equations</p> <p>c. Learn to view linear equations with two variables as an expression of the functional relationship between the variables</p>	<p>Remark: M8A3e. Concept of slope should include an introduction to the idea of constant rate of change.</p>	<p>Removed.</p> <p>Content from the 1989 Japanese standards largely removed, with the exception of the idea of the slope of a linear function being an expression of its constant rate of change.</p>

1989 Japanese Standard	2004 Georgia Standard	Comments
	<p>M8D1. Students will apply basic concepts of set theory. Demonstrate relationships among sets through use of Venn Diagrams. Determine subsets, complements, intersection and union of sets. Use set notation to denote elements of a set.</p> <p>M8D2. Students will determine the number of outcomes related to a given event. Use tree diagrams to find the number of outcomes. Apply addition and multiplication counting principles.</p> <p>M8D3. Students will use the basic laws of probability. Find the probability of simple, independent events. Find the probability of compound, independent events.</p>	<p>Added.</p>