Report on the Effectiveness of Britannica SmartMath System on Student Performance on Standards-based Math Skills Tests

Report on 2009 Student Testing Data

prepared by

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Introduction

Encyclopædia Britannica and PLANETii have collaborated to offer math teachers and school districts Britannica SmartMath. The product is a web-based mathematics formative assessment and summative assessment program that includes a library of math problems, a progress checking and reporting system, and a tool to create tests and assign practice topics to students. It allows teachers to utilize the Britannica SmartMath question bank and virtual manipulatives to better achieve their teaching objectives in class time.

The Britannica SmartMath system is distinguished by its 35,000 item math problem library which covers 91 topics aligned with NCTM and State standards. Additional online content includes downloadable study guides for each topic, animated virtual manipulatives, and descriptive solutions. All content aimed to help students build solid foundations in the five content areas of mathematics: Number and Operations, Measurement, Geometry, Data Analysis and Probability, and Algebra.

Britannica and PLANETii have sought to determine whether the performance of students using the software increased, and thus have commissioned this quantitative study. This study was conducted in 2009, using the results of paired testing data for a cross-section of Britannica SmartMath students from two schools it serves, one in Hong Kong and one in the United States. Using a single group non-experimental pre-posttest design, this study was to determine whether there exists a positive treatment effect between pre- and posttest mathematics skill performance of elementary and middle school students as a result of their use of the Britannica SmartMath system.

The balance of this report describes the Britannica SmartMath treatment further as well as this study methodology, the results of the statistical analysis on data provided, and conclusions and recommendations.

Britannica SmartMath Process and Method

At the core of the Britannica SmartMath system is a summative and formative assessment process whereby a teacher uses the Test Creator section of the software to administer pre- and posttests to their students and then assign via the Topic Library section appropriate adaptive practice and challenge problems, respectively, to their students. The main process is to:

1. Select a specific math topic from within the Test Creator that will be assigned to students for the purpose of assessing their skill level in the topic (a pre-test), then

2. Using the Topic Library feature in the software to let the students access practice and challenge problems and content related to the topic, including formative assessments, and

3. Assessing the student's progress via assigning a topic posttest from the Test Creator feature.

The pre- and posttests each contain 15 questions specifically on one of the 91 topics. The pre- and posttests are different forms of the same topic, quantity and level of

questions. The students are rewarded a certificate for completing the topic. The teacher can then move on to a new topic and the process begins again.

One of the unique characteristics of this system, and treatment that reinforces learning, is the approach to the practice and challenge section. The questions and content that each student practices through are adapted to the student as they use the system. Content is dynamically adapted, shifting to easier or more difficult questions and content based on student input and demonstrated skill level.

The Study

To see whether students' performance on tests of math skills are improving as a result of the Britannica SmartMath practice and challenge system, the results of 15-question topic specific pre- and posttests were reviewed to determine if the results were significantly different using the *student's t-test*. This study assumes that the pre- and posttests are equivalent. PLANETii has verified that all pre and posttests are based on the same learning objectives for each topic. Several screen shots from a sample test are included in the Appendix B. The tests have been independently validated by an experienced credentialed mathematics teacher, showing that they test at grade-level and that the content tested is consistent with skills described by the NCTM standards.

The students who participated in this study are drawn from two sites, one in California, and the other in Hong Kong. PLANETii provided a sampling of recent student testing data. For each school, results from pre- and posttests for 20 random students in each of a random 25 of the 91 topics were prepared and sent to Watson Education for use in the study. Between the two tests, each student participated in the practice and challenge system for approximately one to two weeks, for a total of approximately 4 hours of time on task.

The design of this statistical study is a 'Single Group Pretest-Posttest Design' (Figure 1). This design compares the same group of participants before and after the treatment. The purpose of the single group pretest-posttest design is to determine if participants' demonstrated skill in answering topic-specific test questions improved as a result of the treatment. As is common with most any statistical work, there are limitations and threats to this design which are noted in the Recommendations section of this report.

Figure 1. Single Group Research Design based on Kerlinger (1973)

Students form a single group. The group receives the treatment for a specific time period. O represents the pretest and posttest.

O X O

The null hypothesis of this study is that use of the Britannica SmartMath system will have no positive causal effect on posttest performance. A *t-test* comparing matched pairs of pre- and posttest results was used to statistically determine if there is a significant

difference between the two test scores across the study population. A one-tailed test was used because the effect of the treatment was assumed to be positive.

Once the pre- and posttest data was collected, the data was manipulated in Microsoft Excel, combine and match student pairs of data, and orient the data for *t-test* analysis. The *t-test* analysis was performed on the data collected for each of the sites and topics, a total of 50 tests were run. The calculations were run using the Data Analysis Add-in statistical functionality within Microsoft Excel.

Analysis

The Pearson *r* correlations were generally very good, though there were a small number of results that displayed poor-to-fair correlation. The paired samples were found to correlate highly.

A statistically significant difference in the testing scores between pre- and posttest is shown at the 95% confidence level (Table 1). The null hypothesis was rejected, demonstrating that there was a statistically significant treatment effect between the pre and posttests.

Table 1. Statistical results for California school site

Topic		Mean	Variance	n	Pearson Correlation	Hyp. Mean Diff.	df	t Stat	P(T<=t) one-tail
01M01	Pre-test	0.62	0.019	20	0.73	0	19	-6.90	0.0000006979
	Posttest	0.78	0.017	20					
01N04	Pre-test	0.64	0.017	20	0.82	0	19	-7.65	0.0000001630
	Posttest	0.77	0.018	20					
01S02	Pre-test	0.59	0.015	20	0.83	0	19	-7.61	0.0000001746
	Posttest	0.72	0.019	20					
02D01	Pre-test	0.65	0.015	20	0.88	0	19	-11.00	0.0000000006
	Posttest	0.80	0.013	20					
02M02	Pre-test	0.63	0.006	20	0.36	0	19	-5.53	0.0000123789
	Posttest	0.76	0.009	20					
02N06	Pre-test	0.62	0.006	20	0.51	0	19	-9.31	0.0000000082
	Posttest	0.76	0.004	20					
02S01	Pre-test	0.62	0.005	20	0.78	0	19	-11.90	0.0000000001
	Posttest	0.78	0.009	20					
03D01	Pre-test	0.62	0.006	20	0.65	0	19	-10.43	0.0000000013
	Posttest	0.78	0.008	20					
03M03	Pre-test	0.62	0.006	20	0.75	0	19	-11.69	0.0000000002
	Posttest	0.79	0.010	20					
03N02	Pre-test	0.62	0.006	20	0.56	0	19	-9.56	0.0000000054
	Posttest	0.78	0.008	20					
03S03	Pre-test	0.61	0.009	20	0.62	0	19	-7.18	0.0000003992
	Posttest	0.74	0.010	20					
04D01	Pre-test	0.63	0.007	20	0.58	0	19	-9.04	0.0000000131
	Posttest	0.79	0.008	20					

04M02	Pre-test	0.62	0.010	20	0.79	0	19	-12.70	0.0000000000
	Posttest	0.80	0.007	20					
04N07	Pre-test	0.62	0.010	20	0.76	0	19	-9.87	0.0000000033
	Posttest	0.77	0.009	20					
04S01	Pre-test	0.60	0.011	20	0.80	0	19	-10.79	0.0000000008
	Posttest	0.76	0.011	20					
05A01	Pre-test	0.59	0.012	20	0.73	0	19	-7.65	0.0000001630
	Posttest	0.73	0.011	20					
05D03	Pre-test	0.65	0.008	20	0.65	0	19	-9.65	0.0000000047
	Posttest	0.81	0.007	20					
05M02	Pre-test	0.63	0.010	20	0.65	0	19	-9.20	0.0000000099
	Posttest	0.79	0.007	20					
05N03	Pre-test	0.60	0.011	20	0.47	0	19	-6.99	0.0000005854
	Posttest	0.76	0.009	20					
05S02	Pre-test	0.65	0.007	20	0.68	0	19	-8.34	0.0000000448
	Posttest	0.78	0.009	20					
06A01	Pre-test	0.55	0.010	20	0.81	0	19	-13.40	0.0000000000
	Posttest	0.75	0.012	20					
06D01	Pre-test	0.61	0.009	20	0.28	0	19	-7.31	0.0000003102
	Posttest	0.79	0.009	20					
06M04	Pre-test	0.60	0.011	20	0.79	0	19	-12.90	0.0000000000
	Posttest	0.79	0.009	20					
06N01	Pre-test	0.63	0.014	20	0.81	0	19	-7.65	0.0000001630
	Posttest	0.77	0.018	20					
06S01	Variable 1	0.60	0.006	20	0.73	0	19	-12.70	0.0000000000
	Variable 2	0.77	0.008	20					

Table 2. Statistical results for Hong Kong school site

Topic		Mean	Variance	n	Pearson Correlation	Hyp. Mean Diff.	df	t Stat	P(T<=t) one-tail
01M01	Pre-test	0.70	0.007	20	0.65	0	19	-9.87	0.0000000033
	Posttest	0.85	0.006	20					
01N04	Pre-test	0.68	0.006	20	0.68	0	19	-8.89	0.0000000169
	Posttest	0.83	0.011	20					
01S02	Pre-test	0.64	0.007	20	0.77	0	19	-12.37	0.0000000001
	Posttest	0.81	0.010	20					
02D01	Pre-test	0.71	0.010	20	0.80	0	19	-6.77	0.0000009038
	Posttest	0.82	0.014	20					
02M02	Pre-test	0.68	0.007	20	0.78	0	19	-11.00	0.0000000006
	Posttest	0.82	0.009	20					
02N06	Pre-test	0.68	0.004	20	0.57	0	19	-9.80	0.0000000037
	Posttest	0.84	0.008	20					
02S01	Pre-test	0.68	0.006	20	0.58	0	19	-8.34	0.0000000448
	Posttest	0.82	0.007	20					
03D01	Pre-test	0.68	0.008	20	0.71	0	19	-11.42	0.0000000003
	Posttest	0.85	0.007	20					
03M03	Pre-test	0.69	0.004	20	0.47	0	19	-9.67	0.0000000045
	Posttest	0.86	0.008	20					
03N02	Pre-test	0.69	0.006	20	0.75	0	19	-13.54	0.0000000000
	Posttest	0.87	0.007	20					

03S03	Pre-test	0.70	0.005	20	0.75	0	19	-9.79	0.0000000037
	Posttest	0.85	0.010	20					
04D01	Pre-test	0.67	0.005	20	0.73	0	19	-12.16	0.0000000001
	Posttest	0.83	0.007	20					
04M02	Pre-test	0.69	0.007	20	0.58	0	19	-9.56	0.0000000054
	Posttest	0.85	0.007	20					
04N07	Pre-test	0.66	0.007	20	0.76	0	19	-11.99	0.0000000001
	Posttest	0.84	0.010	20					
04S01	Pre-test	0.67	0.007	20	0.64	0	19	-9.56	0.0000000054
	Posttest	0.83	0.009	20					
05A01	Pre-test	0.60	0.006	20	0.78	0	19	-13.97	0.0000000000
	Posttest	0.78	0.009	20					
05D03	Pre-test	0.67	0.005	20	0.84	0	19	-15.76	0.0000000000
	Posttest	0.82	0.006	20					
05M02	Pre-test	0.66	0.006	20	0.81	0	19	-12.01	0.0000000001
	Posttest	0.82	0.010	20					
05N03	Pre-test	0.66	0.005	20	0.71	0	19	-10.88	0.0000000007
	Posttest	0.84	0.010	20					
05S02	Pre-test	0.69	0.008	20	0.63	0	19	-8.72	0.0000000229
	Posttest	0.85	0.010	20					
06A01	Pre-test	0.67	0.009	20	0.85	0	19	-12.80	0.0000000000
	Posttest	0.82	0.009	20					
06D01	Pre-test	0.68	0.006	20	0.82	0	19	-14.58	0.0000000000
	Posttest	0.85	0.009	20					
06M04	Pre-test	0.66	0.008	20	0.75	0	19	-9.40	0.0000000070
	Posttest	0.81	0.012	20					
06N01	Pre-test	0.67	0.008	20	0.79	0	19	-11.14	0.0000000005
	Posttest	0.82	0.010	20					
06S01	Pre-test	0.65	0.007	20	0.73	0	19	-12.07	0.0000000001
	Posttest	0.82	0.008	20					

Conclusion

The statistical results show a positive treatment effect across all topics analyzed. The improvement in mean scores between pre- and posttests across all topics analyzed ranges from 15 to 20%. The students performed significantly better on a math posttest after using the Britannica SmartMath system.

Figure 2. A graphical comparison of mean pre- and posttest results at California site.

Figure 3. A graphical comparison of mean pre- and posttest results at Hong Kong site.

Recommendations

While these results show a positive treatment effect, there are a number of threats to the statistical results.

Study/Result Threats

- The study is not experimental in design, and could benefit from a more controlled environment. This research is designed to supplement other studies to determine the effectiveness of Britannica SmartMath. As such, this study was easier to implement and a less expensive study than experimental, or quasi-experimental designs. But, this design has inherent limitations, namely participants may improve over time without intervention of any kind, and these changes can be mistakenly attributed to the program under evaluation. This design could not indicate whether the program solely caused improvement in participants; as there is no way to distinguish between changes over time due to other factors and effects specific to the program.

- Another threat is the length of the student treatment effect, and its impact on student retention of topics learned. This study data reflects a length of time between pre- and posttest that averages one to two weeks, which may be a common time frame for teachers to introduce and teach and test the skill level of student on a specific topic, but a longitudinal study, where a summative test is administered after time passes (months), would be useful in determining the treatment's long term effect.

It is recommended that a larger scale, qualitative, experimental study be considered within a controlled environment and time frame. A very sound approach to an experiment would be to have two groups, one which is a 'control', or group that does not receive the treatment, and the other which is 'experimental' or 'treatment', the group which uses the software. The purpose of control is to reduce and bias.

While there are limitations to the statistical results in this study, there are important strengths. The most important conclusion one may draw from the results is that the students performed statistically significantly better on the posttest for each topic.

Appendix A: References

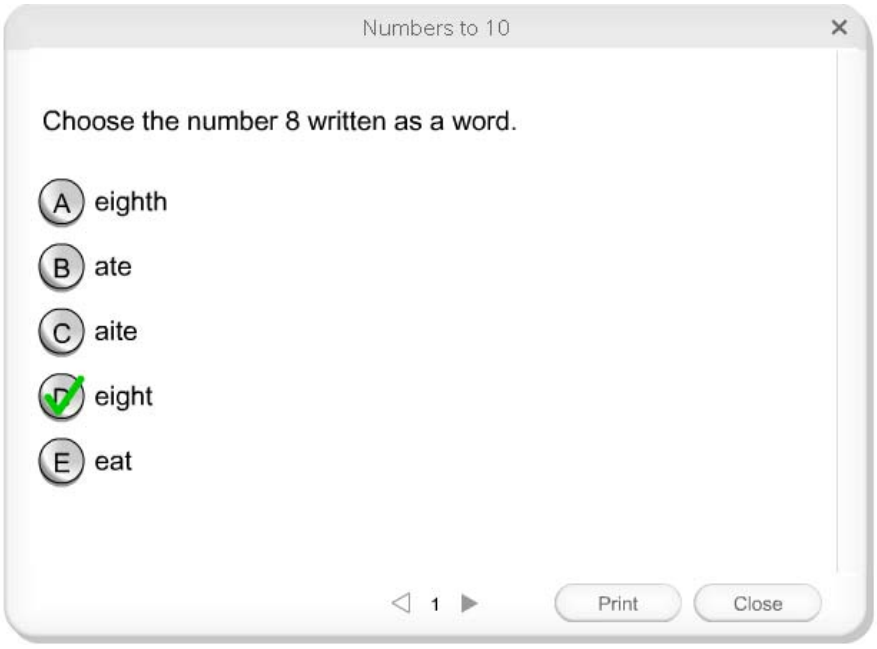
American Educational Research Association (AERA), American Psychological Association (APA), and National Council on Measurement in Education (NCME). (1999). *The Standards for Educational and Psychological Testing*.

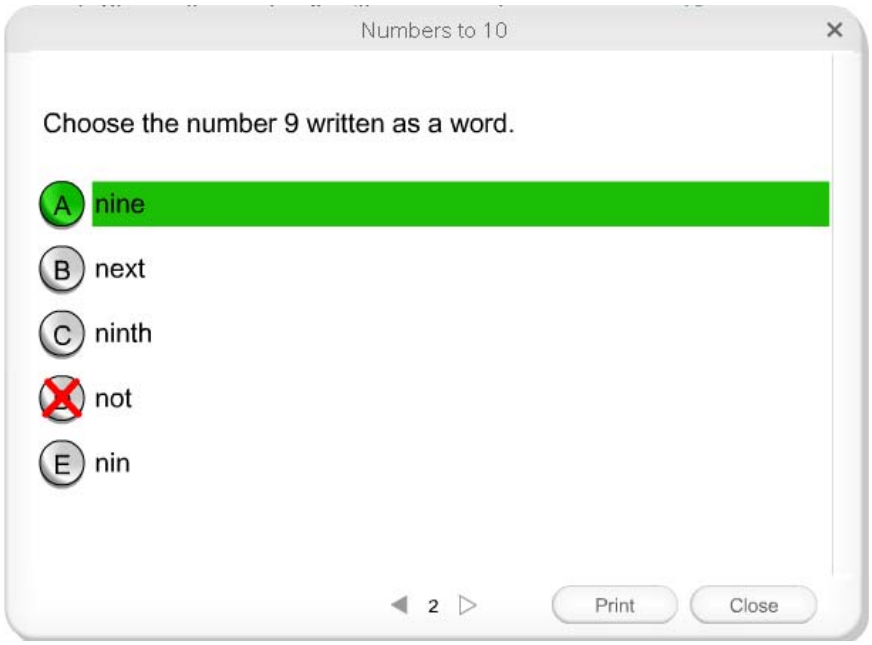
Kerlinger, F. M. (1973). Foundations of behavioral research. New York: Holt Rinehart & Winston.

Trochim, W. (2000). The Research Methods Knowledge Base, 2nd Edition. Atomic Dog Publishing, Cincinnati, OH.

Trochim, W. and Land, D. (1982). Designing Designs for Research. The Researcher, 1, 1, 1-6.

Appendix B: Sample Screen Shots of a Test used in this Study





Appendix C. Sample Portion of Test Alignments to U.S. National Standards

NAT (U.S. National Standards)

01M01 (Length and Distance I test)

NAT. 4.1.2. Compare and order objects according to these attributes.
NAT. 11.3.1. Children use measurable attributes, such as length or weight, to solve problems by comparing and ordering objects. They compare the lengths of two objects both directly (by comparing them with each other) and indirectly (by comparing both with a third object), and they order several objects according to length.
NAT. 12.2. Geometry and Measurement: Children estimate, measure, and compute lengths as they solve problems involving data, space, and movement through space. By composing and decomposing two-dimensional shapes (intentionally substituting arrangements of smaller shapes for larger shapes or substituting larger shapes for many smaller shapes), they use geometric knowledge and spatial reasoning to develop foundations for understanding area, fractions, and proportions.
NAT. 4.1.3. Understand how to measure using nonstandard and standard units.
NAT. 4.2.1. Measure with multiple copies of units of the same size, such as paper clips laid end to end.
NAT. 4.1.1. Recognize the attributes of length, volume, weight, area, and time.

01M03 (Length and Distance II test)

NAT. 4.2.3. Use tools to measure.
NAT. 4.1.2. Compare and order objects according to these attributes.
NAT. 11.3.1. Children use measurable attributes, such as length or weight, to solve problems by comparing and ordering objects. They compare the lengths of two objects both directly (by comparing them with each other) and indirectly (by comparing both with a third object), and they order several objects according to length.
NAT. 12.2. Geometry and Measurement: Children estimate, measure, and compute lengths as they solve problems involving data, space, and movement through space. By composing and decomposing two-dimensional shapes (intentionally substituting arrangements of smaller shapes for larger shapes or substituting larger shapes for many smaller shapes), they use geometric knowledge and spatial reasoning to develop foundations for understanding area, fractions, and proportions.
NAT. 4.1.4. Select an appropriate unit and tool for the attribute being measured.

01N01 (Numbers to 10 test)

NAT. 12.1. Number and Operations: Children use place value and properties of operations to create equivalent representations of given numbers (such as 35 represented by 35 ones, 3 tens and 5 ones, or 2 tens and 15 ones) and to write, compare, and order multi-digit numbers. They use these ideas to compose and decompose multi-digit numbers. Children add and subtract to solve a variety of problems, including applications involving measurement, geometry, and data, as well as nonroutine problems. In preparation for grade 3, they solve problems

involving multiplicative situations, developing initial understandings of multiplication as repeated addition.
NAT. 1.3.3. Use a variety of methods and tools to compute, including objects, mental computation, estimation, paper and pencil, and calculators.
NAT. 2.1.1. Sort, classify, and order objects by size, number, and other properties.
NAT. 12.3. Algebra: Through identifying, describing, and applying number patterns and properties in developing strategies for basic facts, children learn about other properties of numbers and operations, such as odd and even (e.g., 'Even numbers of objects can be paired, with none left over'), and 0 as the identity element for addition.
NAT. 11.1.1. Children use numbers, including written numerals, to represent quantities and to solve quantitative problems, such as counting objects in a set, creating a set with a given number of objects, comparing and ordering sets or numerals by using both cardinal and ordinal meanings, and modeling simple joining and separating situations with objects. They choose, combine, and apply effective strategies for answering quantitative questions, including quickly recognizing the number in a small set, counting and producing sets of given sizes, counting the number in combined sets, and counting backward.
NAT. 1.1.4. Develop a sense of whole numbers and represent and use them in flexible ways, including relating, composing, and decomposing numbers.
NAT. 1.1.5. Connect number words and numerals to the quantities they represent, using various physical models and representations.

01N02 (Numbers to 20 test)

NAT. 12.1. Number and Operations: Children use place value and properties of operations to create equivalent representations of given numbers (such as 35 represented by 35 ones, 3 tens and 5 ones, or 2 tens and 15 ones) and to write, compare, and order multi-digit numbers. They use these ideas to compose and decompose multi-digit numbers. Children add and subtract to solve a variety of problems, including applications involving measurement, geometry, and data, as well as nonroutine problems. In preparation for grade 3, they solve problems involving multiplicative situations, developing initial understandings of multiplication as repeated addition.
NAT. 1.3.3. Use a variety of methods and tools to compute, including objects, mental computation, estimation, paper and pencil, and calculators.
NAT. 11.2.1. Children compare and order whole numbers (at least to 100) to develop an understanding of and solve problems involving the relative sizes of these numbers. They think of whole numbers between 10 and 100 in terms of groups of tens and ones (especially recognizing the numbers 11 to 19 as 1 group of ten and particular numbers of ones). They understand the sequential order of the counting numbers and their relative magnitudes and represent numbers on a number line.
NAT. 1.1.3. Develop understanding of the relative position and magnitude of whole numbers and of ordinal and cardinal numbers and their connections.
NAT. 11.1.1. Children use numbers, including written numerals, to represent quantities and to solve quantitative problems, such as counting objects in a set, creating a set with a given number of objects, comparing and ordering sets or numerals by using both cardinal and ordinal meanings, and modeling simple joining and separating situations with objects. They choose, combine, and apply effective strategies for answering quantitative questions, including quickly recognizing the number in a small set, counting and producing sets of given sizes, counting the number in combined sets, and counting backward.
NAT. 1.1.4. Develop a sense of whole numbers and represent and use them in flexible ways, including relating, composing, and decomposing numbers.
NAT. 1.1.5. Connect number words and numerals to the quantities they represent, using various physical models and representations.

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06S01 (Symmetry I test)

NAT. 3.1.3. Create and critique inductive and deductive arguments concerning geometric ideas and relationships, such as congruence, similarity, and the Pythagorean relationship.
NAT. 3.3.1. Describe sizes, positions, and orientations of shapes under informal transformations such as flips, turns, slides, and scaling.
NAT. 3.1.4. Explore congruence and similarity.
NAT. 3.3.2. Examine the congruence, similarity, and line or rotational symmetry of objects using transformations.
NAT. 3.3.3. Identify and describe line and rotational symmetry in two- and three-dimensional shapes and designs.

06S02 (3D Shapes IV test)

NAT. 3.1.1. Precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties.
NAT. 3.1.2. Classify two- and three-dimensional shapes according to their properties and develop definitions of classes of shapes such as triangles and pyramids.
NAT. 11.3.1. Students relate two-dimensional shapes to three-dimensional shapes and analyze properties of polyhedral solids, describing them by the number of edges, faces, or vertices as well as the types of faces. Students recognize volume as an attribute of three-dimensional space. They understand that they can quantify volume by finding the total number of same-sized units of volume that they need to fill the space without gaps or overlaps. They understand that a cube that is 1 unit on an edge is the standard unit for measuring volume. They select appropriate units, strategies, and tools for solving problems that involve estimating or measuring volume. They decompose three-dimensional shapes and find surface areas and volumes of prisms. As they work with surface area, they find and justify relationships among the formulas for the areas of different polygons. They measure necessary attributes of shapes to use area formulas to solve problems.
NAT. 3.4.1. Draw geometric objects with specified properties, such as side lengths or angle measures.
NAT. 3.4.3. Identify and build a three-dimensional object from two-dimensional representations of that object.

Appendix D. PLANETii Topics

PLANETii Topic Code	Topic Description
01M01	**Length and Distance I**
01M01A	Length and Distance
01M01B	Compare Lengths of Objects and Distances between Objects Directly
01M01C	Compare Lengths of Objects and Distances between Objects with Improvised Units
01M01D	Measure with Appropriate Improvised Units
01M02	**Money I**
01M02A	Identify the Coins of Money
01M02B	Read Price Tags
01M02C	Practice Using Coins through Activities
01M02D	Solve Simple Problems
01M03	**Length and Distance II**
01M03A	Understand the Need for Using Standard Unit
01M03B	Introduce Centimeter (cm)
01M03C	Measure and Compare Lengths of Objects and Distances Between Objects with cm
01M03D	Estimate the Lengths of Objects with "Ever-Ready Rulers"
01M03E	Measure with Appropriate Tools
01M03R	Prerequisite Review
01M04	**Time I**
01M04A	Introduce "Hour"
01M04B	Tell Time in Terms of O'clock
01M04C	Introduce Days of a Week
01M04D	Recognize there are 12 Months in a Year
01M04E	Read out Dates and Days from a Calendar
01N01	**Numbers to 10**
01N01A	Counting, Reading, and Writing
01N01B	Counting on and Counting back
01N01C	Even and Odd Numbers
01N01D	Comparing 2 Groups of Objects with 1-to-1 Correspondence
01N01E	Composition of Numbers 1-10
01N02	**Numbers to 20**
01N02A	Counting, Reading, and Writing
01N02B	Ordinal Numbers and Cardinal Numbers
01N02C	Composition of Numbers 11-18
01N03	**Basic Addition and Subtraction**

01N03A	Concept of Addition and Subtraction
01N03B	Record Addition and Subtraction within 18 Horizontally
01N03C	Understand Concept of Zero through Subtraction
01N03D	Relationship between Addition and Subtraction
01N03E	Commutative Property of Addition through Concrete Examples
01N04	**Numbers to 100**
01N04A	Counting, Reading, and Writing
01N04B	Recognition of the Units and Tens Places
01N04C	Count in Groups of Two, Five, and Ten
01N04D	Composition of Numbers 1 to 100
01N05	**Addition and Subtraction I**
01N05A	Addition within 2 Places, Including Carrying
01N05B	Column Form of Calculation
01N05C	Addition of Three Numbers
01N05D	Subtraction within 2 Places, Excluding Decomposition
01N05E	Solve Simple Problems
01N05F	Estimate the Answers
01S01	**3-D Shapes I**
01S01A	Compare the Attributes of 3-D Objects
01S01B	Recognize 3-D Shapes Intuitively
01S01C	Group 3-D Shapes into Prisms, Pyramids, and Spheres
01S02	**Straight Lines and Curves**
01S02A	Recognize Straight Lines and Curves
01S02B	Identify Straight Lines and Curves Intuitively
01S02C	Make Straight Lines and Curves in a Variety of Ways
01S03	**2-D Shapes**
01S03A	Identify Triangles, Quadrilaterals, Pentagons, Hexagons, and Circles
01S03B	Identify 2-D Shapes Intuitively
01S03C	Identify Squares and Rectangles Intuitively
01S03D	Make 2-D Shapes in a Variety of Ways
02D01	**Pictograms I**
02D01A	Compare Quantity of 3 or More Types of Objects by Arranging them in Lines
02D01B	Read and Discuss Simple Pictograms
02D01C	Construct Pictograms, Using a One-to-One Representation
02M01	**Length and Distance III**
02M01A	Understand the Need for Using a Larger Unit for Measuring
02M01B	Introduce "Meter" (m)
02M01C	Measure and Compare Lengths of Objects and Distances Between Objects with m
02M01D	Measure with Appropriate Measuring Tools

02M01E	Record the Lengths of Objects with Appropriate Measuring Units
02M01F	Estimate the Lengths of Objects with "Ever-Ready Rulers"
02M02	**Time II**
02M02A	Introduce "Minute"
02M02B	Tell Time in Terms of O'clock and Minutes
02M02C	Measure the Duration of Time Spent on Different Activities Using "Hours" and "Minutes"
02M02D	Report the Duration of Time Spent on Different Activities Using "Hours" and "Minutes"
02M02E	Recognize that there are 24 Hours in a Day
02M02F	Develop the Concept of "Morning" and "Afternoon"
02M02G	Tell Time in Terms of "Morning," "Afternoon," "Noon" and "Midnight"
02M02H	Recognize the Number of Days in Each Month
02M02I	Recognize the Number of Days in a Year and Leap Year
02M03	**Money II**
02M03A	Identify Notes and Coins
02M03B	Read Price Tags
02M03C	Exchange Current Notes and Coins
02M03D	Solve Simple Problems--Addition and Subtraction of Money
02M04	**Weight**
02M04A	Develop the Concept of Weight
02M04B	Compare the Weights of Objects Directly
02M04C	Measure and Compare the Weights of Objects Using Improvised Units
02M04D	Understand the Need for Using Standard Units
02M04E	Measure and Compare the Weights of Objects Using "Gram" and "Kilogram"
02M04F	Choose the Appropriate Tools for Measuring
02M04G	Record the Weights of Objects with Suitable Units
02N01	**3-Digit Numbers**
02N01A	Counting, Reading, and Writing
02N01B	Recognize Place Value "Hundreds"
02N01C	Count in Groups of Fifty or Hundred
02N01D	Estimate the Quantity of Objects
02N02	**Addition and Subtraction II**
02N02A	Perform Addition within 3 Places, incl. Carrying, and Addition of 3 Numbers
02N02B	Subtraction within 2 Places, Including Decomposition
02N02C	Solve Simple Problems
02N02D	Estimate the Answers
02N03	**Basic Multiplication**
02N03A	Develop Concept of Multiplication
02N03B	Construct the Multiplication Tables (1-10)
02N03C	Perform Basic Multiplication

02N03D	Commutative Property of Multiplication through Concrete Examples
02N03E	Solve Simple Problems
02N04	**4-Digit Numbers**
02N04A	Counting, Reading, and Writing
02N04B	Recognize the Place Value "Thousands"
02N04C	Count in Groups of Five Hundred and Thousand
02N05	**Addition and Subtraction III**
02N05A	Subtraction within 3 Places, Including Decomposition
02N05B	Associative Property of Addition through Concrete Examples
02N05C	Mixed Operations of Addition and Subtraction (at most 2 operations)
02N05D	Solve Simple Problems
02N05E	Estimate the Answers
02N06	**Basic Division**
02N06A	Develop Concept of Division
02N06B	Sums for Division, Including Sums with Remainders
02N06C	Relationship between Multiplication and Division
02N06D	Solve Simple Problems
02S01	**3-D Shapes II**
02S01A	Identify Prisms and Cylinders Intuitively
02S01B	Identify Pyramids and Cones
02S01C	Recognize Faces Intuitively
02S01D	Group 3-D Shapes
02S01E	Make 3-D Shapes
02S02	**Angles I**
02S02A	Introduce Angles
02S02B	Introduce Right Angles
02S02C	Compare the Sizes of Angles
02S02D	Make Angles in a Variety of Ways
02S03	**The Four Compass Points**
02S03A	Recognize the Four Directions: North, East, South and West
02S03B	Use a Compass to Measure Directions
02S04	**Quadrilaterals I**
02S04A	Develop the Concept of Quadrilaterals
02S04B	Recognize and Identify Quadrilaterals
02S04C	Construct Quadrilaterals in a Variety of Ways
03D01	**Block Graphs**
03D01A	Read and Discuss Block Graphs
03D01B	Construct Block Graphs: 1) Collect Data and Construct Freq. Tables; 2) Construct Graphs Using a One-to-One Representation; 3) Discuss the Block Graphs Constructed
03D01C	Estimate the Average from Block Graphs

03D02	**Bar Charts I**
03D02A	Read and Discuss Simple Bar Charts, and Introduce the Vertical and Horizontal Axes
03D02B	Construct Simple Bar Charts: 1) Use 1-to-1 Representation; 2) Use 2-to-2, 1-to-5, or 1-to-10 Representation; 3) Discuss the Bar Charts Constructed
03D02C	Estimate the Average from Bar Charts
03M01	**Length and Distance IV**
03M01A	Understand the Need for Using a Unit Greater than "Meter" for Measurement
03M01B	Introduce "Kilometer"
03M01C	Compare Lengths of Objects and Distances between Objects Using "Kilometer"
03M01D	Understand the Necessity of Using a Unit Smaller than "Centimeter" for Measurement
03M01E	Introduce "Millimeter"
03M01F	Compare Lengths of Objects and Distances between Objects Using "Millimeter"
03M01G	Choose the Appropriate Tools for Measuring
03M01H	Record Lengths of Objects and Distances Between Objects with Appropriate Units
03M01I	Solve Simple Problems
03M02	**Time III**
03M02A	Introduce "Second"
03M02B	Tell Time
03M02C	Record the Duration of Time for Different Activities Using "Second"
03M02D	Record the Duration of Time for Different Activities Using "Hour and Minute" or "Minute and Second"
03M03	**Capacity**
03M03A	Develop the Concept of Capacity
03M03B	Compare the Capacity of Containers Directly
03M03C	Measure and Compare the Capacity of Containers Using Improvised Units
03M03D	Understand the Need for Using Standard Units
03M03E	Measure and Compare the Capacity of Containers Using "Liter" and "Milliliter"
03M03F	Measure with Appropriate Tools
03M03G	Record the Capacity of Containers with Appropriate Units
03M04	**Time IV**
03M04A	Introduce the "24-Hour Time"
03M04B	Tell Time from 24-Hour Clocks
03M04C	Recognize the Use of "24-Hour Time" in Daily Life Situations
03N01	**5-Digit Numbers**
03N01A	Counting, Reading, and Writing
03N01B	Recognize the Place Value "Ten Thousands"
03N01C	Solve Simple Problems
03N02	**Addition and Subtraction IV**

03N02A	Perform Addition and Subtraction Within Four Places
03N02B	Apply the Commutative and Associative Properties of Addition in Computation
03N02C	Solve Simple Problems
03N02D	Estimate the Answers
03N03	**Multiplication I**
03N03A	Perform Multiplication with Multiplier 1 Digit and Multiplicand 2 Digits
03N03B	Perform Multiplication with Multiplier 1 Digit and Multiplicand 3 Digits
03N03C	Solve Problems
03N03D	Estimate the Answers
03N04	**Division I**
03N04A	Perform Basic Division by Short Division
03N04B	Perform Division with Divisor 1 Digit and Dividend 2 Digits
03N04C	Perform Division with Divisor 1 Digit and Dividend 3 Digits
03N04D	Solve Problems
03N04E	Estimate the Answers
03N05	**Mixed Operations I**
03N05A	Recognize and Use Parentheses in Mixed Operations
03N05B	Perform Mixed Operations of: 1) Multiplication and Addition; 2) Multiplication and Subtraction (For Sums Involving at Most 2 Operations)
03N05C	Solve Problems Involving Addition and Subtraction, Multiplication and Addition, and Multiplication and Subtraction
03N05D	Estimate the Answers
03N06	**Fractions I**
03N06A	Develop the Concept of Fractions as Part of One Whole and a Part of a Set of Objects
03N06B	Recognize the Relationship between Fractions and 1
03N06C	Compare Fractions with Same Denominator or Numerator
03N06D	Solve Simple Word Problems
03S01	**Parallel and Perpendicular Lines**
03S01A	Recognize Parallel Lines
03S01B	Make Parallel Lines in a Variety of Ways
03S01C	Recognize Perpendicular Lines
03S01D	Make Perpendicular Lines in a Variety of Ways
03S02	**Quadrilaterals II**
03S02A	Develop an Understanding of the Characteristics of Squares and Rectangles
03S02B	Develop an Understanding of the Characteristics of Parallelograms
03S02C	Compare the Characteristics of Squares, Rectangles, and Parallelograms
03S03	**Angles II**
03S03A	Recognize Acute Angles and Obtuse Angles
03S03B	Compare the Sizes of Angles

03S04A	Recognize the Simple Characteristics of Triangles
03S04B	Recognize Some Special Triangles, such as Right-Angled Triangles, Isosceles Triangles, Equilateral Triangles and Scalene Triangles
03S04C	Make Triangles
04D01	**Pictograms II**
04D01B	Construct Pictograms of Greater Frequency Counts: 1) Organize and Classify Data Appropriately; 2) Round Off Data to the Nearest Unit; 3) Construct Pictograms, Using a One-to-Ten or a One-to-Hundred Representation
04D01C	Discuss the Pictograms Constructed
04M01	**Perimeter I**
04M01A	Develop the Concept of Perimeter
04M01C	Find the Perimeter of Squares and Rectangles
04M01D	Find the Perimeter of Simple 2-D Shapes
04M02	**Area I**
04M02A	Develop the Concept of Area
04M02B	Direct Comparison of the Area of Surfaces
04M02D	Introduce the Standard Units Square Centimeter and Square Meter
04M02E	Measure the Area of 2-D Shapes Using Square Centimeters and Square Meters
04M02F	Understand and Apply the Formulas for Calculating the Area of Squares and Rectangles
04N01	**Multiplication II**
04N01A	Discover the Associative Property of Multiplication through Concrete Examples (e.g., (3x2) x 5 = 3 x (2x5)
04N01B	Apply the Commutative and Associative Properties of Multiplication in Computation (e.g., 2x8x5 = (2x5) x 8
04N01C	Perform Multiplication with Multiplier 2 Digits and Multiplicand 2 Digits
04N01E	Solve Problems
04N01F	Estimate the Answers
04N02	**Division II**
04N02A	Perform Division with Divisor 2 Digits and Dividend 2 Digits
04N02B	Perform Division with Divisor 2 Digits and Dividend 3 Digits
04N02C	Recognize Divisibility, Divisibility Tests for 2, 5 and 10
04N02D	Solve Problems
04N02R	Prerequisite Review
04N03	**Calculators**
04N03A	Be Familiar with Modern Calculating Devices
04N03B	Recognize the Basic Operations and Functions of a Calculator
04N03C	Use Calculators to Carry Out Activities to Foster Pupil's Number Sense
04N03R	Prerequisite Review
04N04	**Multiples and Factors**

04N04A	Develop an Understanding of Multiples
04N04B	Develop an Understanding of Factors
04N04C	Find Out All the Factors of a Number
04N04D	Explore the Relationship between Factors and Multiples
04N04E	Introduce Prime and Composite Numbers
04N05	**Common Multiples and Common Factors**
04N05A	Develop an Understanding of Common Multiples
04N05B	List the Multiples of Two Numbers, Hence Find the Common Multiples and the Least Common Multiple of the Two Numbers
04N05C	Develop an Understanding of Common Factors
04N05D	List the Factors of Two Numbers, Hence Find the Common Factors and the Highest Common Factor of the Two Numbers
04N05E	Find the Highest Common Factors of Two Numbers by Short Division
04N05F	Solve Word Problems
04N06	**Mixed Operations II**
04N06A	Perform Mixed Operations of: 1) Division and Addition; 2) Division and Subtraction; 3) Division and Multiplication (For Sums Involving at Most 2 Operations)
04N06B	Perform Mixed Operations for Sums involving at most Four Steps
04N06C	Introduce the Distributive Property of Multiplication
04N06D	Solve Problems involving Mixed Operations
04N06E	Estimate the Answers
04N07	**Fractions II**
04N07A	Develop the Concept of Proper Fractions, Improper Fractions and Mixed Numbers
04N07B	Reduce Fractions to their Simplest Form
04N07C	Explore the Methods for Converting Equivalent Fractions
04N07D	Find Common Denominators to Compare Fractions
04N07E	Add and Subtract Fractions with the Same Denominators and Reduce the Answers to the Simplest Form
04N08	**Decimals I**
04N08A	Recognize Decimals as Another Way of Recording Fractions
04N08B	Develop the Concept of Place Value in Decimals
04N08C	Recognize the Use of Decimals in Daily Life Situations
04N08D	Perform the Addition and Subtraction of Decimals up to Two Places of Decimals and for Sums Involving at most Three Operations
04N08E	Solve Problems involving Money, Length, and Distance
04N08F	Estimate the Answers
04S01	**Quadrilaterals III**
04S01A	Develop an Understanding of the Characteristics of Trapezoids and Rhombuses

04S01B	Compare the Characteristics of Different Types of Quadrilaterals
04S01C	Find the Perimeter of Simple 2-D Shapes
04S02	**Fitting and Dissecting Shapes**
04S02A	Make shapes by Fitting 2-D Shapes Together
04S02B	Dissect Polygons and Identify the Shapes Dissected
04S03	**Simple Symmetry**
04S03A	Develop an Understanding of Symmetrical Shapes, and Find the Line(s) of Symmetry
04S03B	Make Symmetrical Shapes
05A01	**Elementary Algebra**
05A01A	Use Symbols or Letters to Represent Numbers
05A01B	Record with Algebraic Symbols (e.g., John is x years old now, how old will he be after 10 years? Record as: (x+10) Years Old
05A02	**Simple Equations I**
05A02A	Understand the Concept of Equations
05A02B	Solve Simple Equations Involving One Step in the Solutions, and Check the Answers (Involving Whole Numbers Only)
05A02C	Rewrite Equations into Equivalent or Simplified Expressions
05A02D	Solve Problems by Simple Equations, Involving at Most One Step in the Solutions
05D01	**Bar Charts II**
05D01A	Read and Discuss Bar Charts
05D01B	Construct Bar Charts: 1) Using a 1-to-50 or a 1-to-100 Representation; 2) Making Charts with Appropriate Scales
05D01C	Read and Discuss Compound Bar Charts
05D01D	Construct Compound Bar Charts and Discuss the Bar Charts Constructed
05D01R	Prerequisite Review
05D02	**Simple Statistics**
05D02A	Introduce Quartile Regions, Average, Range, Mean, Median, and Mode
05D02B	Solve Simple Problems
05D02C	Estimate the Answers
05D03	**Bar Charts III**
05D03A	Read and Discuss Bar Charts of Large Frequency Amounts
05D03B	Construct Bar Charts: 1) Using a 1-to-10,000 or a 1-to-100,000 Representation
05D03C	Estimate the Average from Bar Graphs
05M01	**Area II**
05M01A	Understand and Apply the Formulas for Calculating the Area of Parallelograms, Triangles and Trapezoids
05M01B	Find the Area of Polygons

05M02	**Temperature**
05M02A	Develop the Concept of Temperature
05M02B	Introduce “Celsius” and “Fahrenheit”
05M02C	Read Temperature using Appropriate Tools
05M02D	Use Temperature in Real-Life Examples
05M02E	Convert between Celsius and Fahrenheit
05M02F	Estimate the Answers
05M02G	Solve Problems
05M03	**Volume I**
05M03A	Develop the Concept of Volume
05M03B	Compare the Volume of Objects Intuitively
05M03C	Introduce the Standard Unit "Cubic Centimeter"
05M03D	Measure and Compare the Volume of Objects Using "Cubic Centimeter"
05M03E	Understand the Need for Using a Unit Larger than "Cubic Centimeter"
05M03F	Introduce "Cubic Meter"
05M03G	Understand and Apply the Formulas for Finding the Volume of Cubes and Cuboids
05M04	**Other Counting Systems**
05M04A	Introduce the British System: Distance, Capacity, Weight
05M04B	Measure Objects using British Units and Compare them Intuitively
05M04C	Introduce, Convert, and Use Roman Numerals
05M04D	Estimate the Answers
05M04E	Solve Problems
05N01	**Large and Negative Numbers**
05N01A	Counting, Reading, and Writing
05N01B	Rounding off Large Numbers Using Examples from Everyday Life
05N01C	Introduce Terms Natural Number and Integer
05N01D	Introduce Negative Numbers and Compare with Other Numbers
05N01E	Estimation of Large Quantities
05N02	**Fractions III**
05N02A	Multiply Fractions through Repeated Addition
05N02B	Division of Fractions through Dissection of Shapes
05N02C	Solve Problems
05N02D	Estimate the Answers
05N03	**Decimals II**
05N03A	Develop an Understanding of Multiplication of Decimals, Multipliers Include Whole Numbers Only
05N03B	Develop an Understanding of Division of Decimals, Including a Decimal Divided by a Whole Number and a Whole Number Divided by a Whole Number

05N03C	Find the Approximate Values by Rounding off the Answers
05N03D	Perform Mixed Operations on Decimals for Sums Involving at Most Three Operations
05N03E	Solve Problems involving Money, Length, and Distance
05N03F	Estimate the Answers
05N04	**Fractions IV**
05N04A	Perform Multiplication of Fractions, for Sums Involving at Most Two Operations
05N04B	Solve Problems
05N04C	Estimate the Answers
05N04R	Prerequisite Review
05N05	**Decimals III**
05N05A	Convert Decimals into Fractions
05N05B	Convert Fractions into Decimals, Rounding off the Answers to the Nearest Tenths or Hundredths
05N05C	Compare Fractions by Converting Them into Decimals
05N05D	Solve Problems
05N05E	Estimate the Answers
05N06	**Percentages I**
05N06A	Recognize the Use of Percentages in Daily Life
05N06B	Develop an Understanding of Percentages
05N06C	Convert Percentages into Decimals and Vice Versa
05N06D	Convert Percentages into Fractions and Vice Versa
05N06R	Prerequisite Review
05S01	**The Eight Compass Points**
05S01A	Recognize the Eight Compass Points
05S01B	Find Directions with a Compass
05S02	**3-D Shapes III**
05S02A	Recognize the Characteristics of Cones, Pyramids, Cylinders, Prisms and Spheres
05S02B	Make Nets of Cubes and Cuboids
05S03	**Angles III**
05S03A	Introduce “degree”
05S03B	Identify proper angles (30, 45, 60, 90, 180, 360)
05S03C	Identify and measure angles in 2-D shapes
05S03D	Measure angles using appropriate tools
05S03E	Solve problems
05S03F	Estimate the answers
06A01	**Simple Equations II**
06A01A	Solve Equations Involving at Most Two Steps in the Solutions, and Examine the Results

06A01B	Solve Simple Problems By Equations, Involving at Most Two Steps in the Solutions
06D01	**Broken Line Graphs**
06D01A	Read and Discuss Broken Line Graphs
06D01B	Construct Broken Line Graphs
06D02	**Simple Probability**
06D02A	Acquire an Elementary Understanding of Probability
06D02B	Justify Conclusions involving "and/or" Situations
06D02C	Describe the Probability of Events Happening Using the Following Phrases: 1) Likely / Probable; 2) Unlikely / Not Probable; 3) Fairly Likely; 4) Very Probable; 5) Certain
06D03	**Ratio and Proportion**
06D03A	Introduce Inverse and Direct Proportions
06D03B	Introduce Ratios
06D03C	Solve Problems
06D03D	Estimate the Answers
06D04	**Simple Coordinate Geometry**
06D04A	Introduce the Rectangular Coordinate System
06D04B	Use the Coordinate Plane to Explore Geometric Ideas
06D04C	Make and Use Coordinate Geometry to Specify Locations and to Describe Paths
06D04D	Solve Problems
06D05	**Pie Charts**
06D05A	Reading Pie Charts
06D05B	Making Pie Charts using Compass and Protractor
06M01	**Volume II**
06M01A	Recognize the Relationship between Capacity and Volume
06M01B	Find the Volume of Irregular Solids by Displacement of Water
06M02	**Perimeter II**
06M02A	Develop an Understanding of Circumference
06M02B	Explore the Relationship between the Circumference, the Diameter and the Radius
06M02C	Develop an Understanding of pi
06M02D	Apply the Formula for Circumference
06M03	**Speed**
06M03A	Develop the Concept of Speed
06M03B	Measure Speed Using "Meters per Second" and "Kilometers per Second" as Units

06M03C	Read Travel Graphs
06M04	**Area III**
06M04A	Understand and Apply the Formula for Calculating the Area of a Circle
06M04B	Relationship between Circumference and Area of a Circle
06M04C	Solve Problems
06N01	**Fractions V**
06N01A	Perform Division of Fractions for Sums Involving at Most Two Operations
06N01B	Solve Simple Problems, Excluding Problems on Finding the Original Numbers
06N01C	Estimate the Answers
06N02	**Decimals IV**
06N02A	Multiply Decimals by Decimals
06N02B	Divide Decimals by Decimals
06D02C	Introduce Recurring Decimals
06N02D	Solve Problems
06N02E	Estimate the Answers
06N03	**Percentages II**
06N03A	Solve Simple Problems on Percentages, Including: 1) Find Percentages; 2) Express the Value of a Percentage of a Quantity; 3) Discount
06N03B	Estimate the Answers
06S01	**Symmetry I**
06S01A	Introduce Transformations (Scale, Translation, Reflection, Rotation)
06S01B	Introduce Congruence and Similarity
06S01C	Perform Transformations Showing that Two Shapes are Congruent or Similar
06S01D	Identify the Line of Rotational Symmetry in 3-D Figures
06S01E	Solve Problems
06S02	**3-D Shapes IV**
06S02A	Recognize the Vertices, Edges and Faces of 3-D Shapes
06S02B	Make Frameworks of Prisms and Pyramids
06S02C	Explore the Relationship between the Number of Edges and the Number of Sides of the Bases of Prisms and Pyramids
06S02D	Explore the Relationship between the Number of Vertices and the Number of Sides of the Bases of Prisms and Pyramids
06S02E	Explore and Design Nets of Prisms
06S02F	Make Pyramids and Prisms
06S02G	Recognize the Different Sections of Prisms, Pyramids and Spheres
06S03	**Circles**
06S03A	Develop an Understanding of the Properties of Circles, Center, Radius, Diameter and Circumference

06S03B	Draw Circles in a Variety of Ways