The Montessori Method and Minnesota Academic Standards in Mathematics Prioritized by Saint Paul Public Schools

By

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Abstract

Montessori education is a widely misunderstood teaching philosophy. Many in the world acknowledge and value the success of Montessori programs, yet are unaware of the learning support that can result from the use of beautiful manipulative materials used in a carefully structured Montessori classroom environment. Public schools are beginning to adopt this method before becoming equipped and educated on the philosophy. This study was performed in a public Montessori school in the Midwest with twelve kindergarten students learning mathematic skills through Montessori materials provided to the classroom. The Montessori materials in this classroom were aligned with the standards that the district found pertinent to the success of the students. The assessments given to the students were the same assessments that all of the kindergarten students in this district were given. For example one of the learning targets is, "I can count to 20 with objects," 100% of the students met the district expectation for this skill. If Montessori schools begin to align materials to the standards that are valued in society and prove that the method is successful through the same tests given to students who learn in a traditional model, the effectiveness of this pedagogical approach to maximize students' learning will be more widely recognized.

LITERATURE REVIEW

Montessori Misconceptions, Following the Child and Everyday Math

Maria Montessori's philosophy is becoming more recognized around the world. Increased community awareness has resulted in Montessori pedagogy being adopted by public school systems. There are differences in the way that instruction is carried out amongst the Montessori schools and traditional schools in the public realm. It is very important to have good communication with the districts that have included Montessori in its programs in order to develop strong public Montessori schools. All of the schools in a public program are held to the same expectations and standards across the board. Montessori teachers need to both remain true to the method and meet the needs of the district. All of the materials in the Montessori classroom are designed to educate the whole child and entice a child's love of learning. Standardized testing has an enormous impact on instruction. The amount of time devoted to testing or test preparation is counter to Montessori pedagogy and the content may not readily equate to the scope, sequence and materials used in the Montessori method. This creates much pressure on a Montessori teacher who needs to reassure district personnel, school administrators and parents that the Montessori method will provide an excellent education for the children.

The Misconceptions

In this pedagogy, Montessori materials are viewed as essential to provide students with an education that is designed specifically for the individual or small groups. Each Montessori material has a very specific purpose to teach the children concepts in every discipline. Many individuals who are unfamiliar with the Montessori method, much like myself when I began my Montessori journey, may see much of the Montessori work as play. Matt Bronsil, a Montessori teacher, received a phone call from a concerned parent one day after school. This parent was concerned that her daughter was not being challenged enough at school because her daughter came home

to tell her that she sat at a rug all day and played with beads with a friend in the class. There are many misconceptions about the materials in the Montessori classroom and Bronsil responded with the following questions in mind. "The first thing I did was to listen, and, while listening, I tried to discern the answers to these questions: 1. What activity is the mother describing to me? 2. What are the parents' perceptions of the work? 3. Is there anything specific the parent is interested in having the child learn? If so, is the child ready to do that?" (Bronsil, 2005, p. 48). After having a conversation with the mother, Bronsil was able to respond in a way that informed the parent and put her at ease. "After my explanation, Cindy's mother laughed at how something so complex can be understood by the child as simply "playing on a rug with beads" (Bronsil, 2005, p. 49). This parent was not the only person to misunderstand the purpose of a material in the Montessori classroom or the reason a skill is taught in a certain way.

Murray is aware of these misconceptions and addressed the issues with a survey that was conducted to determine the public's knowledge on Montessori education. A main question on that survey was, "Ever Heard of Montessori Education" (Murray, 2012, p. 18)? The result of the responses was, 67%, yes, and 33% no. This shows that some people are unaware of the Montessori method and its benefits. The most concerning response was, "…less than 10% understood Montessori educators' avoidance of extrinsic rewards in order to develop children's internal motivation" (Murray, 2012, p. 19). This is one of the most important aspects of Montessori's work. She knows a child is capable of independence and has the drive within to succeed. That drive cannot be awoken if adults intrude on the progress with trivial praise or objects as rewards. It is critical that people become educated on the philosophy of Maria Montessori in order for her legacy to thrive. These misconceptions are very prevalent in society, which is why it is important to shed light on this issue.

The Philosophy

The Montessori materials were created *for* the child. With that in mind the child is provided with instruction, as he or she is ready for each material. The child is at the center and guide of all instruction in a Montessori classroom. Adults are creating standardized tests and curricular goals reflecting what adults see fit for a child to learn and know at certain ages. Will Crain discusses this issue in the article *The Standards Movement: A Child-Centered Response***,** "…child centered educators have argued that our focus should not be on our goals, but on the child as a growing organism. Instead of asking, 'What do we want the child to know and be able to do?' we should ask, 'What capacities is the child naturally motivated to develop at his or her current stage?' Instead of thinking about our own goals, we should consider the child's interests and needs" (Crain, 2003, p. 8)? With adult pressures comes forced curriculum and topics that a child may not be interested in at all which results in a lack of motivation to learn. "In the child-centered view, the problem of motivation in conventional schools lies not with the child but with the curriculum" (Crain, 2003, p.10).

Montessori has created an environment that supports children. Montessori teachers in the public sector need to trust a method whose success is becoming well documented. "Since child-centered educators do not believe in aligning education to standardized tests, we might expect that child-centered children would score lower on them. But generally speaking, child-centered classrooms produce about the same standardized test scores as conventional schools do" (Crain, 2003, p.12). Crain is not the only person interested in the comparing Montessori schools and traditional schools. Jane Carol Manner also researched the results in standardized tests. She specifically focused on the public sector and found that the math scores were not significantly different however the reading skills were significantly higher than those in a traditional method school. Manner believes that the lack of performance on the math tests is due to the importance of the concrete understanding of math before abstraction. The standardized tests are very abstract tests. She believes to truly know which educational strategy is best for children it is crucial to follow the students past their Montessori classroom education to see their gains in the upper grades (Manner, 2007).

There will always be a comparison amongst theorists and researchers about which method is best to educate the young child. The Montessori method is challenged by the thoughts and ideas of others and this is how it will always be. The challenges make the method stronger. Maria Montessori did not want her work to become stagnant with her death. She wanted her work to continue to improve and change with the times. The philosophy remains the same yet there are new factors that were non-existent in her lifetime. The role of mathematics in early childhood education has taken dramatic changes throughout history. Olivia N. Saracho and Bernard Spodek take a look at the history of math education and young children. After considering all of the changes and adaptations one conclusion was clear:

> Paralleling the increasing awareness of the importance of mathematics for our society and for children's development, there has been an extraordinary increase in awareness of the importance of mathematics education for young children. Children acquire a substantial amount of informal knowledge of mathematics before entering school. When young children—including infants, pre-schoolers, and kindergartners—are provided with appropriate experiences, they are able to extend their knowledge of mathematics. (Saracho and Spodek, 309)

The Montessori method agrees with this excerpt. Young children are capable of gaining knowledge. Children absorb so much information everyday and if the opportunity is missed a child can suffer trying to catch up. Society needs to keep standards high while keeping in mind the interests, development and needs of individual children.

Standardized Tests

Though the Montessori philosophy may not agree with standardized tests, it does not make the tests disappear. The tests are there for everyone to take. The tests are how schools are rated. Performance on these tests plays a crucial role in whether or not public schools continue running as usual or need to make changes. So let's take a look at these standards in a positive way being that it is not going to change in the near future. Linda Dacey and Drew Polly addressed the common core standards in an article titled, *CCSSM: The Big Picture.* "The Common Core State Standards for Mathematics (CCSSM) were "designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers" (CCSSI 2010) (Dacey, Drew Polly, 2010, p.378). The standards have been created and modified with the intent to provide students with an education to prepare each individual for the future. The goal is to have all of the students learning similar things at similar times to allow for fluidity amongst all schools. There is a want for equality in education. The standards and tests are what are in place to ensure that that is happening in schools across the country.

Many of the standards can be met in several different ways. Schools all around are creating different ways to meet the standards. Like Montessori there are misconceptions about the Common Core Standards. Valerie N. Faulkner focused on different habits that have been formed in reference to the standards. These habits limit an individual's knowledge of a topic, such as the term equality. Many teachers inform the students that equal means "the same as." Faulkner suggests defining equal as "same value as." According to Faulkner, "the definition "same as" is mathematically incorrect and leads to misconceptions. Equals means that two things are the same based on one attribute- their quantitative value" (Faulkner, 2013, 59). Montessori instructors do not need to stray from the philosophy or materials if one can utilize language and strategies like this one to prepare the youth.

Along with standardized testing there are report cards and standards to deal with. Such reports based on standards may not easily reflect what is being taught in the classroom, especially if it is a Montessori school. Erin Conway and Amanda Fink,

students at the University of St. Catherine saw this as an issue and researched the topic. The study included parents and teachers who had been teaching from two years to thirty years. The goal of the study was to see if there was a better way to present a student's progress that was more understandable to parents and more effective to use for teachers. The study is titled, "Aligning the State Developmental Standards to Toddler and Early Childhood Montessori Practical Life and Sensorial Materials." The study found that most parents felt comfortable with the original reports but when presented with the report that was aligned with the materials used in the Montessori classroom 97% of the parents were highly satisfied with the outcome and preferred the aligned report over the original (Conway, 21). In reference to the teacher opinions 100% of the teachers found the aligned report much easier and effective to work with in the classroom (Conway, 19). It is important that the Montessori method is understood and if adaptations need to be made for a better understanding it is something that should be looked into deeply especially at the public school level.

The Child

All teachers have a common goal, to best prepare students for the future. Some teachers are bound by curriculum, some are driven by standards, and some are driven by the success and interest of the child. In all circumstances each teacher has his or her own philosophy. Rather than argue about which instruction is best Douglas H. Ryniker decided to go directly to the source to discover which students were more involved and excited to be in school. He used the Tricket and Moos Classroom Environment Scale to compare student attitudes toward their classroom environments. Results of the study show that students who studied in a Montessori school were more involved with their classrooms than those in a traditional public school. Montessori students demonstrated more ownership in their education rather than waiting on the teacher for their education (Ryniker, 2001).

It is not only the children that are enjoying this environment, companies all over the world are moving to working models that resemble the Montessori environment. Martha Torrence believes it is now the time for Maria Montessori's work to thrive.

> This complex set of competencies, now termed "21st-century skills," includes not only knowledge in core areas but also technological prowess, environmental literacy, cross-cultural communication skills, and the ability to solve complex problems, think creatively, and work collaboratively. Children, future citizens of the world, will need to think across disciplines, reach across cultures, and embrace new knowledge at every stage of their lives. (Torrence, 2012 , p. 18)

If we begin by preparing the child in an environment that is highly motivating, integrates disciplines and is most like the working environment the child will face in the future, the results could be astronomical.

Conclusion of Literature Review

It has been recognized that the Montessori method creates a learning environment that supports all of the children learning in the room. There are misconceptions and misunderstandings about the curriculum and those need to be addressed when the opportunity arises to discuss the Montessori method. Many worry about students performing on standardized tests and many wonder if Montessori is the best education to prepare a child for the high expectations of schooling systems in the United States of America. What I hope to achieve with my research is to demonstrate that the Montessori method support children in meeting the standards and can lead to success in the standardized testing. My focus will be on the mathematics discipline. Montessori teachers in the public school system need to stay true to the Montessori philosophy while educating students. Remaining true would be much easier with the district being well informed about the Montessori philosophy. Communication and understanding with the district can lead to more support, more materials and more Montessori appropriate professional development. The question I pose for this research is: Can the Montessori method meet the needs of the Minnesota State Standards that are prioritized by Saint Paul Public Schools?

Introduction

Education in the United States is highly valued and closely monitored. The standards that are set for students all over the country are set very high. All but seven of the states in U.S.A are guided by the Common Core State Standards for Mathematics. Those seven states have created standards for mathematics that apply to that state. Minnesota is one of the states that have not adopted the CCSSM. Minnesota created its own set of standards, the Minnesota Academic Standards for Mathematics. Working in the Saint Paul Public School district instruction and expectations are guided by the standards that have been created to help students prepare for the future. SPPS prioritized these standards in regards to importance and relevance to the MCA tests. All of the schools in the district are expected to perform well on all assessments; however, the prioritized assessments are turned in and reviewed by district personnel. There are many different philosophies for teaching in the district. The teaching method used at the public school in this study is based on the Montessori philosophy. Though it is great that public schools are now beginning to adopt this well documented way of educating it does not come without conflict or difficulties. The curriculum, workshops and assessments need to be aligned to that of the traditional method of education. The goals for this research were to align the Montessori materials and method to the standards that are in place for kindergarten in SPPS and assess the knowledge of the students by the end of the year. Proving that the Montessori method is sufficient to help students meet the standards in mathematics was the ultimate goal for this research.

Methodology

Participants and setting

Students in a Children's House classroom (prek and kindergarten) participated in this study. Twelve kindergarteners were the focus group. The kindergarteners learned in a Montessori environment full of manipulatives to guide learning throughout the year. It was found that the math standards addressed three main disciplines of Montessori education: mathematics, sensorial and language. With wanting to prove that the students were meeting the expectations of the district the students were given the district assessments: the assessments used to collect data. The prioritized skills are heavily assessed (See Appendix A). The district wants to see students master these skills before moving to the next level of education. Based off of the skills that are thought to be the most important, SPPS created a progress report that guides the assessments and instruction in the district (See Appendix B). The learning targets become the focus of the assessment and of the learning that is taking place in the classroom. The strands on this progress report refer to the MCA test. The students are being prepared in kindergarten for a standardized test that will be taken in third grade. This shows the importance of these skills to the district and the state. There is an assessment at the beginning of the year that assesses the initial knowledge of each student and at the end of the year there is an assessment that gauges the mathematical knowledge of the students. These are the assessments that are required to report to the district at the beginning of the year and at the end of the year (See Appendix C). With this research, remaining true to the expectations of the district was crucial, therefore, the district's

form of assessing was used to show the knowledge the students gained throughout the year. The data that is most important to the district for math are the skills on this assessment. I used these assessments to determine whether or not the students in this Montessori classroom could perform as expected from the district. The overall results show great success in the Number and Operation strand and some discrepancies in the Geometry & Measurement and Algebra strands.

Procedure:

There are seven areas of the standards that are prioritized and reported at the end of the year for kindergarten. The learning targets that are focused on are:

1. I can recognize two-dimensional shapes.
2. I can recognize three-dimensional shapes.
3. I can count forward to 20 **without** objects.
4. I can read numbers from 0 to at least 31.
5. I can count forward to 20 **with** objects.
6. I can match a number to a set of objects.
7. I can complete shrinking patterns.

For each of these learning targets, Montessori materials were aligned to the skill that was being taught. The Montessori albums created at the University of Wisconsin- River Falls were used to determine which materials reach the learning targets. Each lesson that is given in a Montessori classroom has direct and indirect aims. If the aims or indirect aims correlated to the learning target then it was used to teach the specific skill. Notice that there are many different aims that apply to each material used for each lesson; the skills that are directly aligned are italicized. All of these materials were taught to the kindergarten students in this study throughout the year when the students showed interest or when the student was ready for the presentation.

Learning Target 1: I Can Recognize Two-Dimensional Shapes

The shapes that the students must recognize and name for this assessment are: circle, rectangle, hexagon, square, triangle, and trapezoid.

The materials used and available in this Montessori classroom are as follows:

Constructive Triangles (See Appendix D)
Direct *Aims:*

- *to develop visual discrimination of form*
- to explore the Constructive Triangles before presentation
- to develop concentration, order, coordination, and independence
- to develop skill in observation and judgments
- *to prepare for geometry*

Indirect Aims:

- to create various plane figures using the blue triangle.

Triangular Box (See Appendix E)
Direct Aims:

- *to refine visual discrimination of geometric forms*
- to develop an appreciation for line and form
- to develop concentration, order, coordination, and independence
- to develop skill in observation and making judgments
- *to prepare for geometry- to develop an understanding of the various plane figures contained in an equilateral triangle*

Indirect Aims:

- to form an equilateral triangle, equal to the size of the grey equilateral triangle, using each set of colored triangles, one at a time

Small and Large Hexagonal Boxes (See Appendix F)
Direct Aims:

- *to refine visual discrimination of geometric forms*
- to develop an appreciation for line and form
- to develop concentration, order, coordination, and independence
- to develop skill in observation and making judgments
- *to prepare for geometry- to develop an understanding of the various plane figures contained in a hexagonal figure*

Indirect Aims:

- *to form plane figures contained in a hexagon: rhombus and trapezoid (small hexagonal)*
- *to form four plane figures: hexagon, equilateral triangle, rhombus, and parallelogram (large hexagonal)*

Metal Insets (See Appendix G)

Direct Aim:

- to support the sensitive period for language, specifically writing

Indirect Aim:

- to refine pencil control

*Students were taught the names of the metal inset shapes and were provided three-part cards identifying the names for independent work.

Results:

I can recognize two-dimensional shapes. The results show that 42% of the students were considered proficient in this skill by the end of the year, it would be great to see this number a bit higher, 42% is not enough students to indicate that the needs were met for this skill in this setting. It is important to note the gains that most of the students had in recognizing his or her shapes. Ten out of the twelve students recognized more shapes than in the fall, that means 83% of the students made gains in the knowledge of two-dimensional shapes.

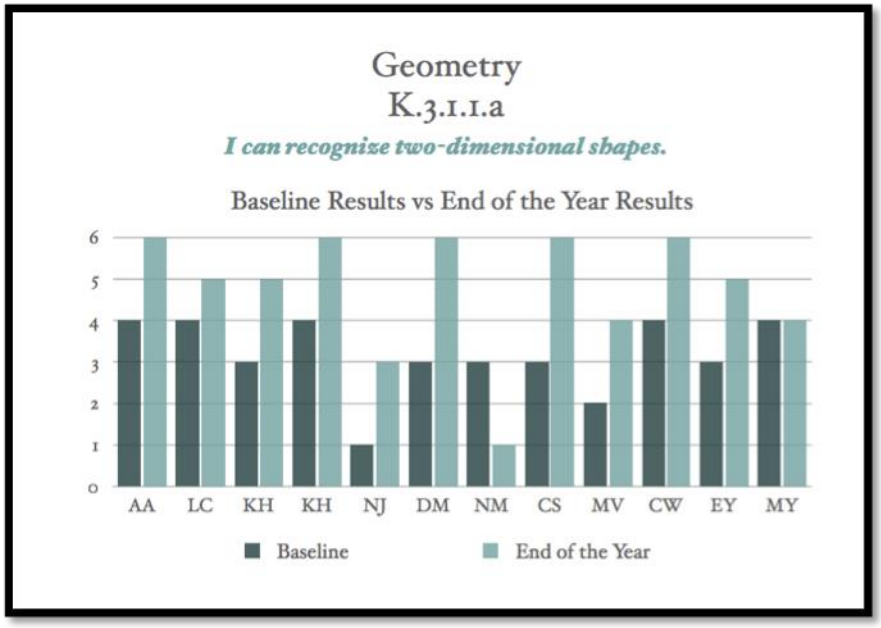

Figure 1: Comparison of Baseline Scores and EOY Scores. Learning Target: I can recognize 2D shapes.

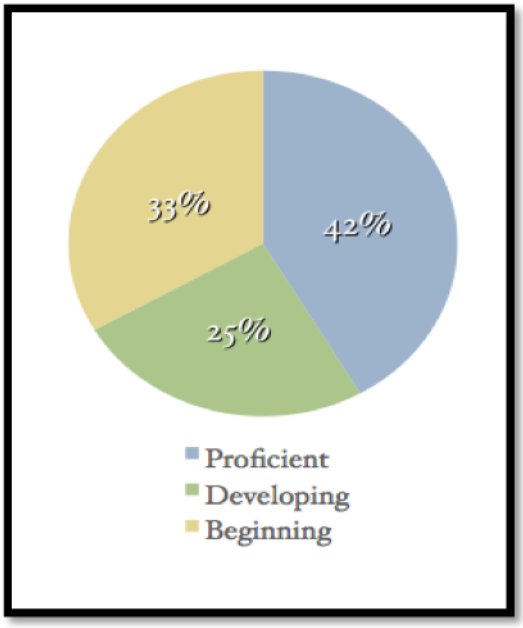

Figure 2: Results of EOY Assessment: I can recognize 2D shapes.

The Impact of these Results: *Significant change needs to occur.* Change and adaptations need to be made to the instruction of two-dimensional shapes in this classroom. A change that could be made is the amount of materials available to this new Montessori classroom. It is not cheap to fund a fully stocked Montessori classroom and the school in this study does its best to add materials whenever money is available. A material that would have helped in aiding this learning target would have been the geometric cabinet, which this classroom does not have *yet.* Another improvement that may help the results of this learning target is continuing an interest level throughout the entire year on two-dimensional shapes. Students' reading and language skills may also have contributed to the results of this study. It is difficult to learn and name the shapes independently if a student cannot read the names of the shapes. The overall results of this specific learning target and assessment show that the classroom needs more experience with shapes and shape naming. In order to provide that for the students all Montessori materials need to be purchased and available for the students. If the results continue to stay the same, some supplemental material and instruction may need to be added while still guiding the children with the Montessori philosophy.

Learning Target 2: I can recognize three-dimensional shapes.

The shapes that the students need to recognize and name in the assessment are: sphere, cube, cone and cylinder.

The materials used and available in this Montessori classroom are as follows:

Knobbed Cylinders (See Appendix H)
Direct Aims:

- *to develop visual discrimination of height and diameter*
- to develop order, concentration and independence
- *to develop skill in observing and making judgments*

Indirect Aim:

- to replace each cylinder into its correct hole in the block

Knobless Cylinders (See Appendix I)

Direct Aims:

- *to develop visual discrimination*
- to develop order, concentration, creativity, coordination, and independence
- *to develop skill in observation and making judgments*

Indirect Aims:

- to order the cylinders horizontally and/or vertically

Pink Tower (See Appendix J)

Direct Aims:

- *to develop visual discrimination of size*
- to develop order and concentration
- to develop appreciation for the beauty of design
- *to develop skill in observation and the ability to make judgments*
- to train voluntary muscles
- to prepare for math- understanding the concept of ten

Indirect Aim:

- to build a tower with the largest cube forming the base and the smallest cube forming the apex

Brown Stair (See Appendix K)

Direct Aims:

- *to develop visual discrimination of thickness*
- to develop order, concentration, coordination and independence
- *to develop skill in observation and making judgments*
- to concretely experience the concept of ten

Indirect Aims:

- to build a set of stairs in an orderly progression of prisms from thickest to thinnest

Geometric Solids (See Appendix L)

Direct Aims:

- *to develop visual discrimination of solid geometric forms*
- to develop concentration, coordination, independence, and order
- *to develop skill in observation and making judgments*
- to develop Stereognostic sense
- *to prepare for geometry*

Indirect Aim:

- *to identify the various geometric forms using visual and Stereognostic senses*

Results:

I can recognize three-dimensional shapes. The results for this assessment are a bit more promising than those of the two-dimensional shapes with 67% of the students identifying as proficient and recognizing the four shapes required by the learning target. This skill is not assessed at the beginning of the year in SPPS.

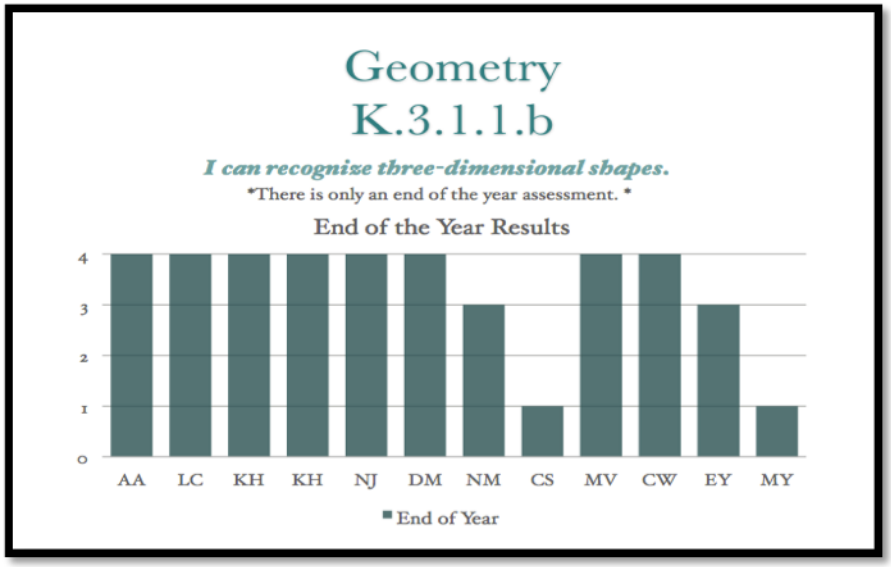

Figure 3: Comparison of EOY Scores. Learning Target: I can recognize 3D shapes.

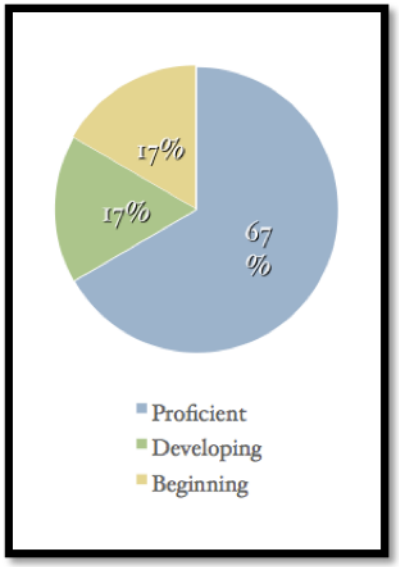

Figure 4: Results of EOY Assessment. I can recognize 3D shapes.

The Impact of these Results

Some change needs to occur. The results show that there could still be some improvement on the teaching of three-dimensional shapes, 67% is not enough to consider this skill effectively taught in this setting. Much like the two-dimensional materials, language skills may be one of the barriers in naming three-dimensional shapes. Group lessons may help with this barrier. A child who knows the names could work with students who do not know all of the shape names yet. Part of the Montessori

philosophy is teaching others the knowledge an individual has, helping others while refining skills. More three-part cards could be provided to the students to develop shape-naming skills. Three-part cards are cards that are comprised of a control card (the answer card), a picture card and a card with a label. The students match the label with the photo or image and check the answers with the control card. Overall the instruction needs to change a bit to meet the expectations of the district.

Learning Target Three: I can count to 20 without using objects.

The materials used and available in this Montessori classroom are as follows:

20 Board (See Appendix M)
(not in album)
Direct Aims:
- *to practice placing tiles 1-20 in sequence*
- *to reinforce memory of numerals 1-20*
- to reinforce concepts of place value
- *to reinforce rote counting to 20*

Indirect Aims:
- to develop the mathematical mind, concentration, order, accuracy
- to prepare for bead chains
- to prepare for 100 board

100 Board (See Appendix N)
Direct Aims:
- *to practice placing tiles 1-100 in sequence*
- *to reinforce memory of numerals 1-100*
- to reinforce concepts of place value
- *to reinforce rote counting to 100*

Indirect Aims:
- to develop the mathematical mind, concentration, order, accuracy
- to prepare for bead chains

Number Scroll (See Appendix O)
(not in RF album)
Direct Aims:
- *to reinforce memory of numerals 1-9,999*

- to reinforce concepts of place value
- *to reinforce counting*

Indirect Aims:

- to develop the mathematical mind, concentration, order, accuracy

Results: I can count to 20 without using objects. These results are spectacular, the results that were hoped to be found in this study! There were 92% of students exceeding the expectations of the district. The students are expected to reach numbers 20-31 to be considered proficient in this skill, anything above that is considered exemplary. All of the students could count to at least 20 with no objects.

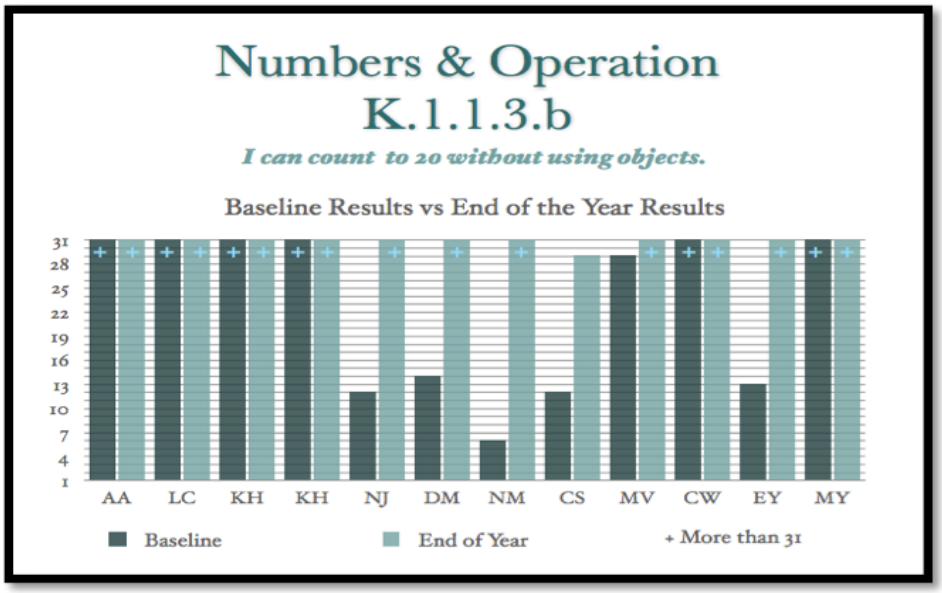

Figure 5: Comparison of Baseline Scores and EOY Scores. Learning Target: I can count to 20 without using objects.

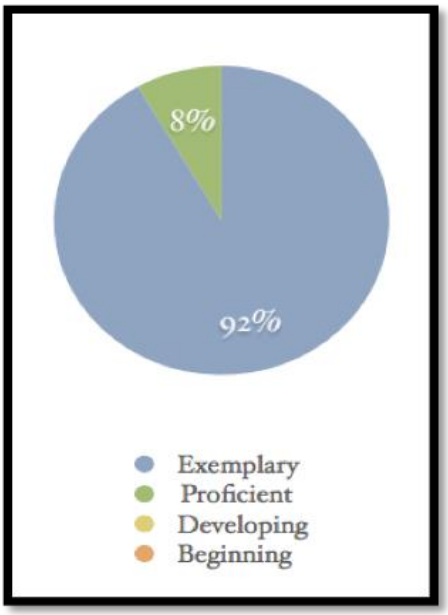

Figure 6: Results of EOY Assessment. I can count to 20 without using objects.

Impact of these Results: *No change needs to occur.* The materials and instruction in this case appear to be more than sufficient enough to meet the needs of the district for this standard. The results demonstrate that students in this Montessori classroom are learning counting skills beyond expectations. The manipulatives and

repetition with the material provide the students with ample opportunity to master the skill of counting. Though the instruction won't stop progressing for this learning target, it is clear that the Montessori method works for this standard. This is substantial information to be able to provide to the district when defending the effectiveness of the Montessori method.

Learning Target Four: I can read numbers from 0 to at least 31.

The materials used and available in this Montessori classroom are as follows:

Sandpaper Numerals (See Appendix P)
Direct Aims:
- to practice tracing numerals in the directions the numerals will be formed
- *to learn the names associated with the symbols 0-9*

Indirect Aims:
- to prepare for writing numerals
- to prepare for associating numeral with quantity

Number Rods and Numerals (See Appendix Q)
Direct Aims:
- *to associate quantities 1-10 with their numeric symbol*
- *to understand the sequence of numbers*
- to prepare for abstraction

Indirect Aims:
- to prepare for abstraction
- to develop a sense of accuracy, order, and concentration
- to prepare for the decimal system/operations

Spindle Box (See Appendix R)
Direct Aims:
- reinforce correspondence
- *introduce concept of zero*
- *to associate 1-10 with their numeric symbols*
- to prepare for abstraction

Indirect Aims:
- introduce sets
- to prepare for abstraction
- to develop a sense of accuracy, order, and concentration

Numerals and Counters (See Appendix S)
Direct Aims:
- reinforce 1 to 1 correspondence
- count to make sets
- teach odd and even
- *sequence quantities 1-10*
- *sequence numerals 1-10*

Indirect Aims:
- prepare for counting by 2
- prepare for decimal system

Short Bead Stair (See Appendix T)
Direct Aims:
- *to count by ones*
- to practice building a triangle, sensorially, with the beads
- *to practice matching the beads to their appropriate number*

Indirect Aims:
- to prepare for addition and subtraction
- to prepare for abstraction

Teen Boards (See Appendix U)
Direct Aims:
- *to practice building the quantities for 11-19*
- *to practice forming the numerals for 11-19*
- *to learn the names of the numbers 11-19*
- to reinforce the place values of tens and ones

Indirect Aims:
- to develop a strategy and system for decoding two-digit numerals to prepare for abstraction

Ten Boards (See Appendix V)
Direct Aims:
- *to practice building and recognize quantities for 10-99*
- *to practice forming the numerals for 10-99*
- *to learn names of the numerals 10-99*
- *to learn the quantities and symbols for 10-99*
- to reinforce the place values of tens and ones; two digit numbers

Indirect Aims:
- preparation for operations
- preparation of abstraction

100 Board (See Appendix N)
Direct Aims:

- *to practice placing tiles 1-100 in sequence*
- *to reinforce memory of numerals 1-100*
- to reinforce concepts of place value
- *to reinforce rote counting to 100*

Indirect Aims:

- to develop the mathematical mind, concentration, order, accuracy
- to prepare for bead chains

Number Scroll (See Appendix O)
(not in RF album)
Direct Aims:

- *to reinforce memory of numerals 1-9,999*
- to reinforce concepts of place value
- *to reinforce counting*

Indirect Aims:

- to develop the mathematical mind, concentration, order, accuracy

Results: I can read numbers from 0 to at least 31. The results of this assessment resulted in 83% of the students in this study meeting the expectations for the district, 75% exemplary and 8% proficient. The students who did not meet the expectations you can see still had great growth from the beginning of the year to the end.

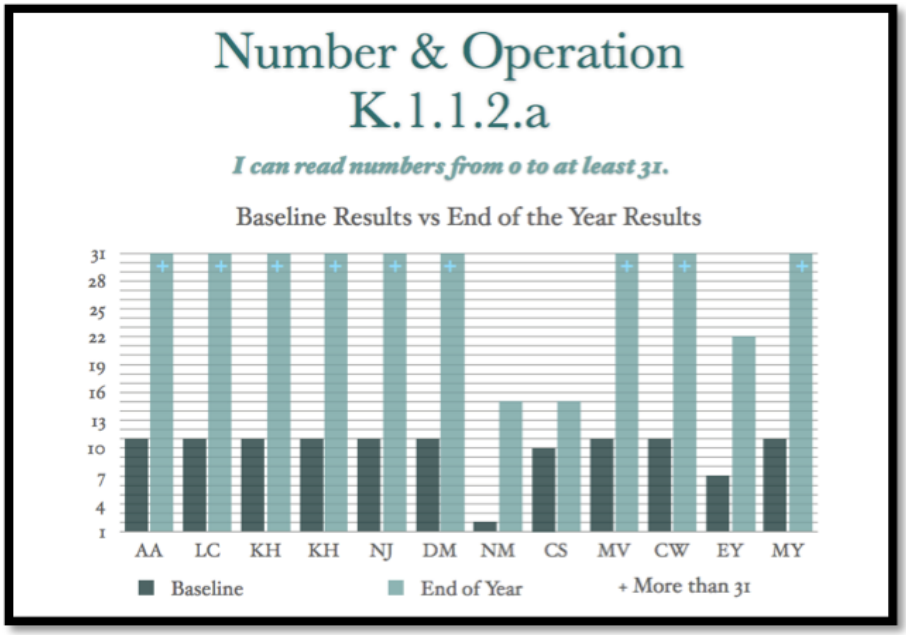

Figure 7: Comparison of Baseline Scores and EOY Scores. Learning Target: I can read numbers from 0 to at least 31.

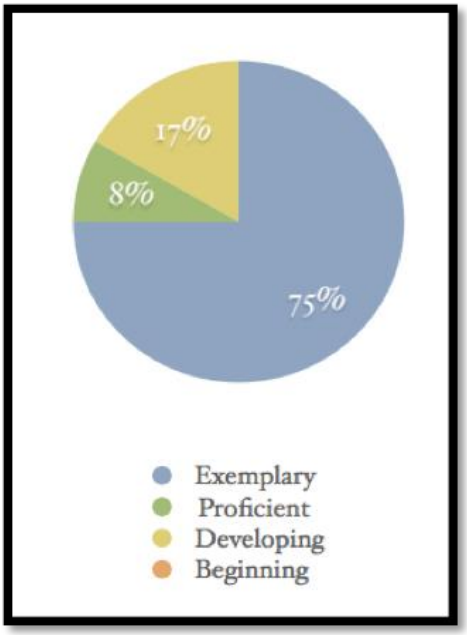

Figure 8: Results of EOY Assessment: I can read numbers form 0 to at least 31.

Impact of these Results

Some change needs to occur. This assessment demonstrates that the Montessori method was effective for most of the students in meeting this standard. The method did not fail any of the students; all of the students were able to make gains in the amount of numbers that could be read by the end of the year compared to that of the beginning of the year. There are students, however, that could use more experience with number reading. In order to do this there need to be some adjustments to the instruction given. For example, increased time with naming numerals would likely increase the amount of numbers a child can recognize by the end of the year.

Learning Target Five: I can count forward to 20 with objects.

The materials used and available in this Montessori classroom are as follows:

Number Rods and Numerals (See Appendix Q)
Direct Aims:
- *to associate quantities 1-10 with their numeric symbol*
- *to understand the sequence of numbers*
- to prepare for abstraction

Indirect Aims:
- to prepare for abstraction
- to develop a sense of accuracy, order, and concentration
- to prepare for the decimal system/operations

Spindle Box (See Appendix R)
Direct Aims:
- reinforce correspondence
- *introduce concept of zero*
- *to associate 1-10 with their numeric symbols*
- to prepare for abstraction

Indirect Aims:
- introduce sets

- to prepare for abstraction
- to develop a sense of accuracy, order, and concentration

Numerals and Counters (See Appendix S)
Direct Aims:
- reinforce 1 to 1 correspondence
- count to make sets
- teach odd and even
- *sequence quantities 1-10*
- *sequence numerals 1-10*

Indirect Aims:
- prepare for counting by 2
- prepare for decimal system

Short Bead Stair (See Appendix T)
Direct Aims:
- *to count by ones*
- to practice building a triangle, sensorially, with the beads
- *to practice matching the beads to their appropriate number*

Indirect Aims:
- to prepare for addition and subtraction
- to prepare for abstraction

Teen Boards (See Appendix U)
Direct Aims:
- *to practice building the quantities for 11-19*
- *to practice forming the numerals for 11-19*
- *to learn the names of the numbers 11-19*
- to reinforce the place values of tens and ones

Indirect Aims:
- to develop a strategy and system for decoding two-digit numerals to prepare for abstraction

Ten Boards (See Appendix V)
Direct Aims:
- *to practice building and recognize quantities for 10-99*
- *to practice forming the numerals for 10-99*
- *to learn names of the numerals 10-99*
- *to learn the quantities and symbols for 10-99*
- to reinforce the place values of tens and ones; two digit numbers

Indirect Aims:
- preparation for operations
- preparation of abstraction

Results: I can count forward to 20 with objects. It is important to note that for this assessment the students were only assessed up to 20 objects, which is considered proficient by these standards. Time became an issue when assessing all of the high priority benchmark skills at the end of the year. The outcome of the results exhibit that **all** (100%) of the students were able to reach proficiency level by the end of the year.

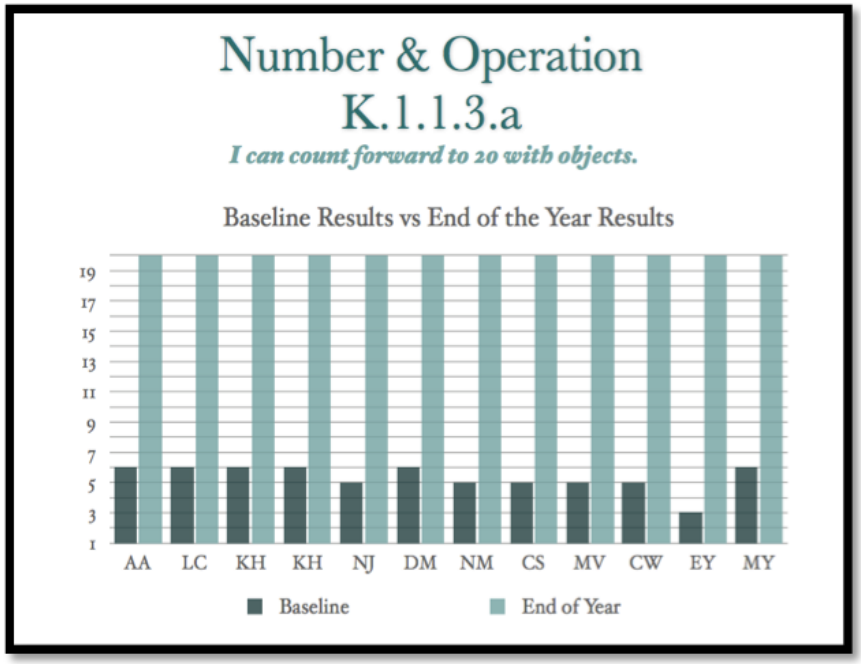

Figure 9: Comparison of Baseline Scores and EOY Scores. Learning Target: I can count forward to 20 with objects.

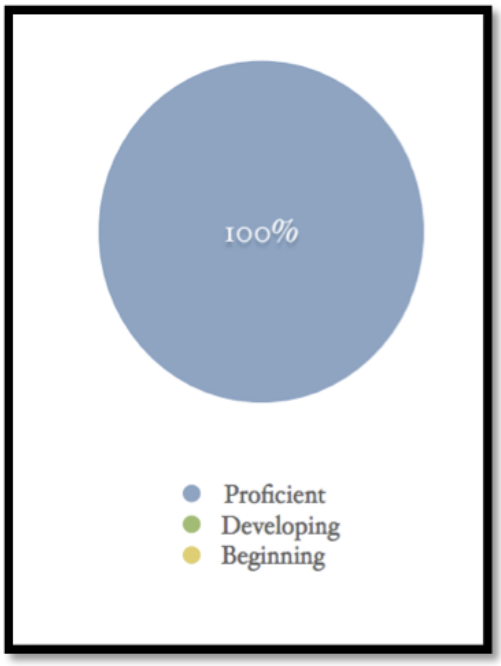

Figure 10: Results of EOY Assessment: I can count forward to 20 with objects.

There was an extreme growth with all of the students in this skill.

Impact of these Results

No change needs to occur. The Montessori method was effective in guiding the students through the skill of counting with objects. Materials used in this study were

manipulative and critical to the learning of counting objects. The Number and Operation strand on the progress report has been fulfilled in this aspect. According to these results it can be said that the students in this room have a solid understanding of this concept and the instruction should continue to help the students grow further, surpassing the expectation.

Learning Target 6: I can match a number to a set of objects.

The materials used and available in this Montessori classroom are as follows:

Number Rods and Numerals (See Appendix Q)
Direct Aims:
- *to associate quantities 1-10 with their numeric symbol*
- *to understand the sequence of numbers*
- to prepare for abstraction

Indirect Aims:
- to prepare for abstraction
- to develop a sense of accuracy, order, and concentration
- to prepare for the decimal system/operations

Spindle Box (See Appendix R)
Direct Aims:
- reinforce correspondence
- *introduce concept of zero*
- *to associate 1-10 with their numeric symbols*
- to prepare for abstraction

Indirect Aims:
- introduce sets
- to prepare for abstraction
- to develop a sense of accuracy, order, and concentration

Numerals and Counters (See Appendix S)
Direct Aims:
- reinforce 1 to 1 correspondence
- count to make sets
- teach odd and even
- *sequence quantities 1-10*
- *sequence numerals 1-10*

Indirect Aims:

- prepare for counting by 2
- prepare for decimal system

Short Bead Stair (See Appendix T)

Direct Aims:

- *to count by ones*
- to practice building a triangle, sensorially, with the beads
- *to practice matching the beads to their appropriate number*

Indirect Aims:

- to prepare for addition and subtraction
- to prepare for abstraction

Teen Boards (See Appendix U)

Direct Aims:

- *to practice building the quantities for 11-19*
- *to practice forming the numerals for 11-19*
- *to learn the names of the numbers 11-19*
- to reinforce the place values of tens and ones

Indirect Aims:

- to develop a strategy and system for decoding two-digit numerals to prepare for abstraction

Ten Boards (See Appendix V)

Direct Aims:

- *to practice building and recognize quantities for 10-99*
- *to practice forming the numerals for 10-99*
- *to learn names of the numerals 10-99*
- *to learn the quantities and symbols for 10-99*
- to reinforce the place values of tens and ones; two digit numbers

Indirect Aims:

- preparation for operations
- preparation of abstraction

Results: I can match a number to a set of objects. The majority of the students were able to count a set of objects and point to the number of objects in random order. The percentage of students who were able to score proficient on this test was 83%. Leaving only one student at a developing skill level and one student beginning skill level according to the district.

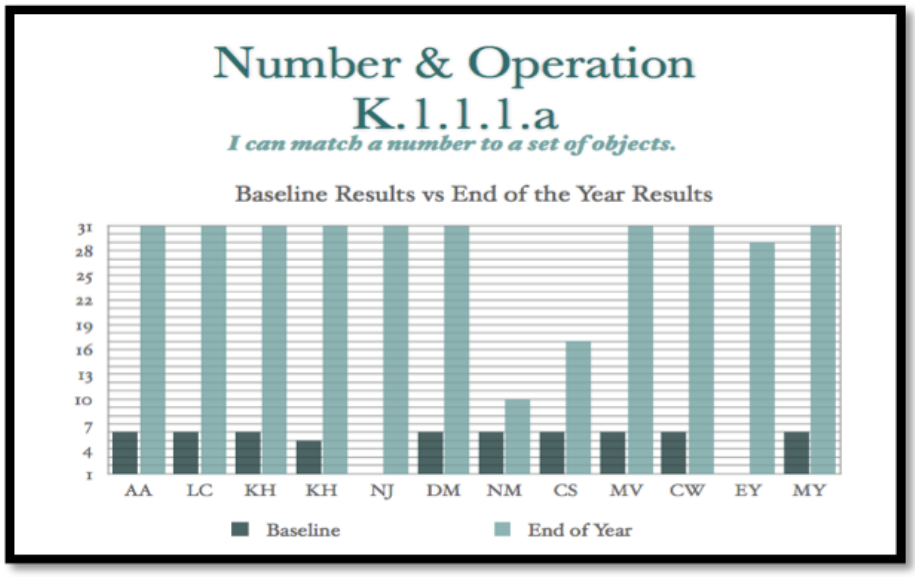

Figure 11: Comparison of Baseline Scores and EOY Scores. Learning Target: I can match a number to a set of objects.

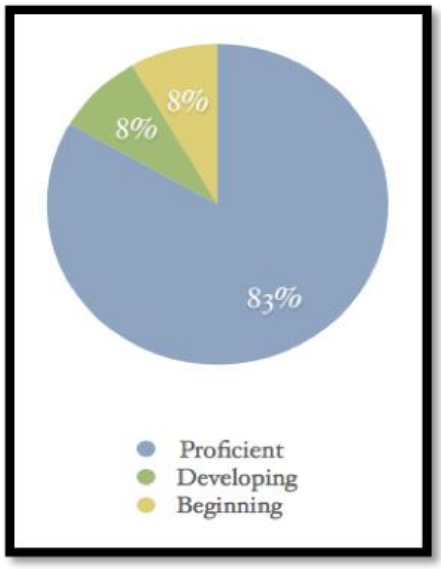

Figure 12: Results of EOY Assessment: I can match a number to a set of objects.

The Impact of these Results: *Some change needs to occur.* Referencing the results one can see that the Montessori method aided in the success of student learning. There were two students unable to reach the standard. With the goal of this study, it is necessary for all of the students to meet the standards. In order to push the students further presentations can be given more frequently to reinforce the student's skill. More group lessons and work could be encouraged to help students who are trying to secure mathematic skills.

Learning Target Seven: I can complete shrinking patterns.

The materials used and available in this Montessori classroom are as follows:

Knobbed Cylinders (See Appendix H)
Direct Aims:
- *to develop visual discrimination of height and diameter*
- to develop order, concentration and independence
- *to develop skill in observing and making judgments*

Indirect Aim:
- to replace each cylinder into its correct hole in the block

Pink Tower (See Appendix J)
Direct Aims:
- *to develop visual discrimination of size*
- to develop order and concentration
- to develop appreciation for the beauty of design
- *to develop skill in observation and the ability to make judgments*
- to train voluntary muscles
- to prepare for math- understanding the concept of ten

Indirect Aim:
- to build a tower with the largest cube forming the base and the smallest cube forming the apex

Brown Stair (See Appendix K)
Direct Aims:
- *to develop visual discrimination of thickness*
- to develop order, concentration, coordination and independence
- *to develop skill in observation and making judgments*
- to concretely experience the concept of ten

Indirect Aims:
- to build a set of stairs in an orderly progression of prisms from thickest to thinnest

Red Rods (See Appendix W)
Direct Aims:
- *to develop visual discrimination of length*
- to develop order, concentration, coordination, and independence
- *to develop skill in observation and making judgments*
- to prepare for mathematics- linear dimension and concept of ten

Indirect Aims:
- to build the set of stairs by placing the rods in order from longest to shortest

Knobless Cylinders (See Appendix I)
Direct Aims:

- *to develop visual discrimination of size*
- to develop order, concentration, creativity, coordination, and independence
- *to develop skill in observation and making judgments*

Indirect Aims:

- to order the cylinders horizontally and/or vertically

Number Rods (See Appendix X)
Direct Aims:

- *to practice arranging the rods in numerical order according to length*
- to acquire a concept of ten
- to memorize the sequence of numbers 1-10

Indirect Aims:

- to prepare for associating a quantity with a symbol
- to prepare for the decimal system
- to develop order, concentration, coordination, and independence

Results: I can complete shrinking patterns. This learning target has the highest variety of assessment results: 33% above standards, 33% meeting the standard, 25% developing the skill and 8% are beginning to understand the skill. This is an end of the year skill for kindergarten and the majority of the students (66%) were able to reach the expectations required on the assessment. If the student completed all four patterns on the assessment the score was exemplary.

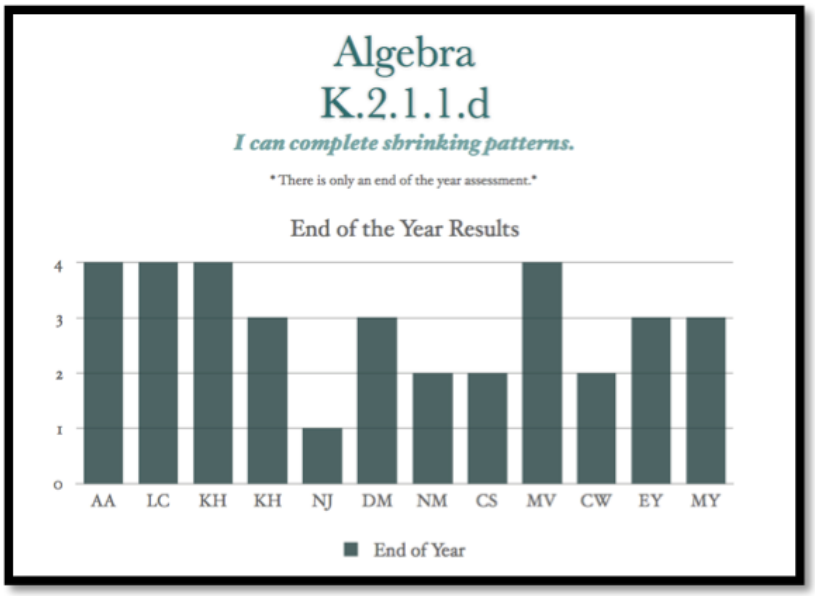

Figure 13: Comparison of EOY Scores. Learning Target: I can complete shrinking patterns.

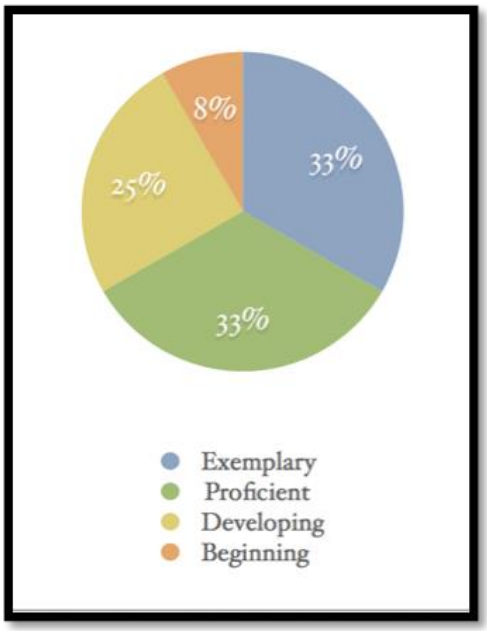

Figure 14: Results of EOY Assessment: I can complete shrinking patterns.

The Impact of the Results

Some change needs to occur. It is clear that not all of the students understand this algebraic skill. The instruction needs to be adapted to help all children learn this skill proficiently. Something as simple as introducing the term, *shrinking pattern,* early in the year while working with the sensorial materials may do the trick. Something more substantial than that may have to be done in order for the students to abstract the skill from the concrete manipulatives to the paper pencil assessment. Extensions could be made connected to the materials to help the students see the patterns demonstrate in a 2D fashion. Many of the students began to record the shrinking patterns from the materials on the paper. This could be on option for beginning abstraction.

Overall Results

Through the data collected in the study it was determined that the Montessori method was very effective in the Number and Operation strand of the standards. Four of the ten learning targets had a success rate of 83% or higher, meaning little or no change needs to occur to the instruction or material provided for the students. According to the district the students in this classroom are prepared for Number and Operation skills in first grade and have a good foundation for skills that will need to be secured by the time the students need to take the MCA's. The study also found that skills in Geometry & Measurement fell short of what was expected. There has to be some changes in the way this standard is approached in the classroom. This could be solved by small adjustments to the instruction provided to the students. The same can be said for algebraic thinking. Patterns are an important aspect of math and students need to know that there are more than just ABAB patterns out there. The materials in the Montessori setting offer a plethora of experiences for a child, especially in the sensorial area for patterning. The important thing to keep in mind is the language used while teaching the students these materials. The materials can be used in the same way, teach the same skills that the materials are intended for while using the language required for the standards. For instance, when manipulating the pink tower the term shrinking pattern could be used to prepare the child for the assessment that the district requires.

The Impact of this Study

This study has revealed that the Montessori method provides a very solid foundation for number and operational skills and falls short of meeting the geometry and measurement skills, along with algebra. This type of study will never end. It is important to always observe the child, monitor the progress in learning and adapt when necessary. Maria Montessori created her philosophy by following the child and that is what will continue to be done. The study has demonstrated that there need to be some changes in instruction in some components of the curriculum. Educating is a never ending learning experience and the child will always be the top priority. In the public sector it is important to open communication with the district. Montessori schools need just as much support as the traditional schools. The study will continue next year by purchasing some new materials and tracking the progress of the students in class to discover if those materials fill the gaps in the results. Another topic to explore is approaching the district about more direct support to the Montessori method schools and teachers. The study can offer support when presenting needs to the district. With this information the district can be informed of the success and what can be improved in the classroom. Teachers need more support from the district on applying and improving as a guide in the Montessori classroom. The workshops and curriculum need to be meaningful and helpful in the journey of becoming a Montessori teacher rather than a battle between the two different philosophies. This data can begin those conversations and hopefully initiate more change in the district in regards to Montessori education in SPPS.

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Appendix A
Minnesota State Academic Standards Prioritized by SPPS

Minnesota Academic Standards in Mathematics

SPPS - Prioritized by Teachers in Spring 2012- High Priority Benchmarks Highlighted and Medium Priority Underlined

Pre-Kindergarten
(numbered and aligned by SPPS PK Department)

Number & Operation	Algebra	Geometry & Measurement
Understand the relationship between quantities and whole numbers up to 10. P.1.1.1 Demonstrates understanding of one-to-one correspondence between objects and numbers. (48) P.1.1.2 Recognizes numerals by name and shape (50) P.1.1.3 Demonstrates ability to count in sequence to 10 and beyond. (49) P 1.1.4 Demonstrates ability to state the number that comes next up to 9 or 10. (49a) **Use objects and pictures to represent situations involving combining and separating.** P 1.2.1 Uses simple strategies to solve mathematical problems. (57)	**Recognize, create and extend patterns.** P 2.1.1 Recognizes and duplicates a simple pattern. (51)	**Recognize and sort basic two-dimensional shapes.** P 3.1.1 Sorts objects into subgroups by one or two characteristics. (52) P 3.1.2 Identifies and names common colors (red, orange, yellow, green blue, purple, brown, black) and two-dimensional shapes (square, circle, oval, triangle, rectangle, trapezoid, rhombus, diamond). (53) **Compare and order objects according to location and measurable attributes.** P 3.2.1 Uses words that show understanding of order and position of objects. (54) P 3.2.2 Recognizes objects can be measured by height, length, weight and time. (55) P 3.2.3 Makes comparisons between at least two groups of objects. (56)

Kindergarten

Number & Operation	Algebra	Geometry & Measurement
Understand the relationship between quantities and whole numbers up to 31. K.1.1.1 Recognize that a number can be used to represent how many objects are in a set or to represent the position of an object in a sequence. K.1.1.2 Read, write, and represent whole numbers from 0 to at least 31. Representations may include numerals, pictures, real objects and picture graphs, spoken words, and manipulatives such as connecting cubes. K.1.1.3 Count, with and without objects, forward and backward to at least 20. K.1.1.4 Find a number that is 1 more or 1 less than a given number. K.1.1.5 Compare and order whole numbers, with and without objects, from 0 to 20. **Use objects and pictures to represent situations involving combining and separating.** K.1.2.1 Use objects and draw pictures to find the sums and differences of numbers between 0 and 10. K.1.2.2 Compose and decompose numbers up to 10 with objects and pictures.	**Recognize, create, complete, and extend patterns.** K.2.1.1 Identify, create, complete, and extend simple patterns using shape, color, size, number, sounds and movements. Patterns may be repeating, growing or shrinking such as ABB, ABB, ABB or ●,●●,●●●.	**Recognize and sort basic two- and three-dimensional shapes; use them to model real-world objects.** K.3.1.1 Recognize basic two- and three-dimensional shapes such as squares, circles, triangles, rectangles, trapezoids, hexagons, cubes, cones, cylinders and spheres. K.3.1.2 Sort objects using characteristics such as shape, size, color and thickness. K.3.1.3 Use basic shapes and spatial reasoning to model objects in the real-world. **Compare and order objects according to location and measurable attributes.** K.3.2.1 Use words to compare objects according to length, size, weight and position. K.3.2.2 Order 2 or 3 objects using measurable attributes, such as length and weight.

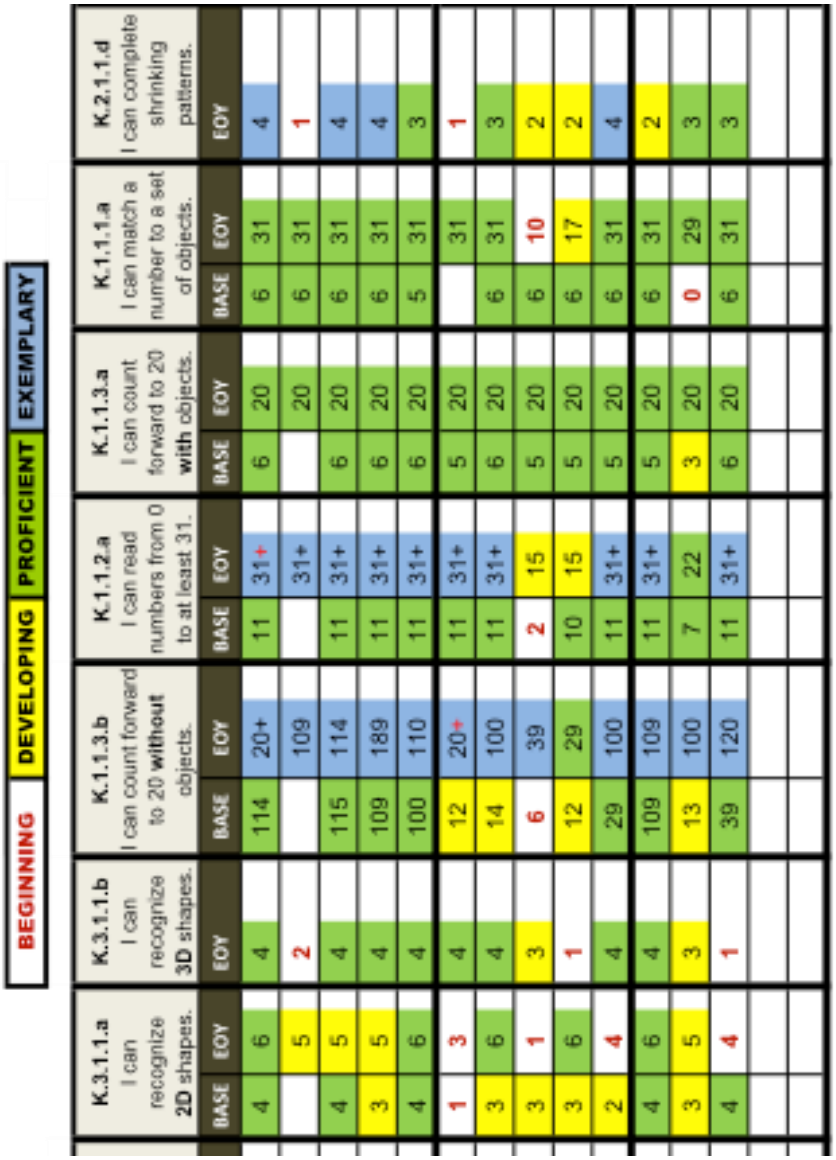
Appendix B
Progress Report for SPPS based on Standards

Kindergarten Math
High Priority Benchmarks & Learning Targets
(progress monitor on electronic spreadsheet and progress report)

MCA-III Strand	SPPS High Priority Benchmark	Learning Target
Number & Operation	**K.1.1.1** Recognize that a number can be used to represent how many objects are in a set or to represent the position of an object in a sequence.	a.) I can match a number to a set of objects. b.) I can use a number to show position.
	K.1.1.2 Read, write, and represent whole numbers from 0 to at least 31. Representations may include numerals, pictures, real objects and picture graphs, spoken words, and manipulatives such as connecting cubes.	a.) I can read numbers from 0 to at least 31. b.) I can write numbers from 0 to at least 31. c.) I can show quantities from 0 to at least 31.
	K.1.1.3 Count, with and without objects, forward and backward to at least 20.	a.) I can count forward to 20 with objects. b.) I can count forward to 20 without objects. c.) I can count backwards from 20 with objects. d.) I can count backwards from 20 without objects.
Algebra	**K.2.1.1** Identify, create, complete, and extend simple patterns using shape, color, size, number, sounds and movements. Patterns may be repeating, growing or shrinking.	a.) I can identify simple patterns. b.) I can complete and extend repeating patterns. c.) I can complete and extend growing patterns. d.) I can complete and extend shrinking patterns. e.) I can create simple patterns.
Geometry & Measurement	**K.3.1.1** Recognize basic two- and three-dimensional shapes such as squares, circles, triangles, rectangles, trapezoids, hexagons, cubes, cones, cylinders and spheres.	a.) I can recognize two-dimensional shapes. b.) I can recognize three-dimensional shapes.
	K.3.1.2 Sort objects using characteristics such as shape, size, color and thickness.	a.) I can sort objects by shape. b.) I can sort objects by size. c.) I can sort objects by color. d.) I can sort objects by thickness. e.) I can use shapes to model real-world objects.
	K.3.2.1 Use words to compare objects according to length, size, weight and position.	a.) I can compare objects by length. b.) I can compare objects by size. c.) I can compare objects by weight. d.) I can compare objects by position.

Appendix C

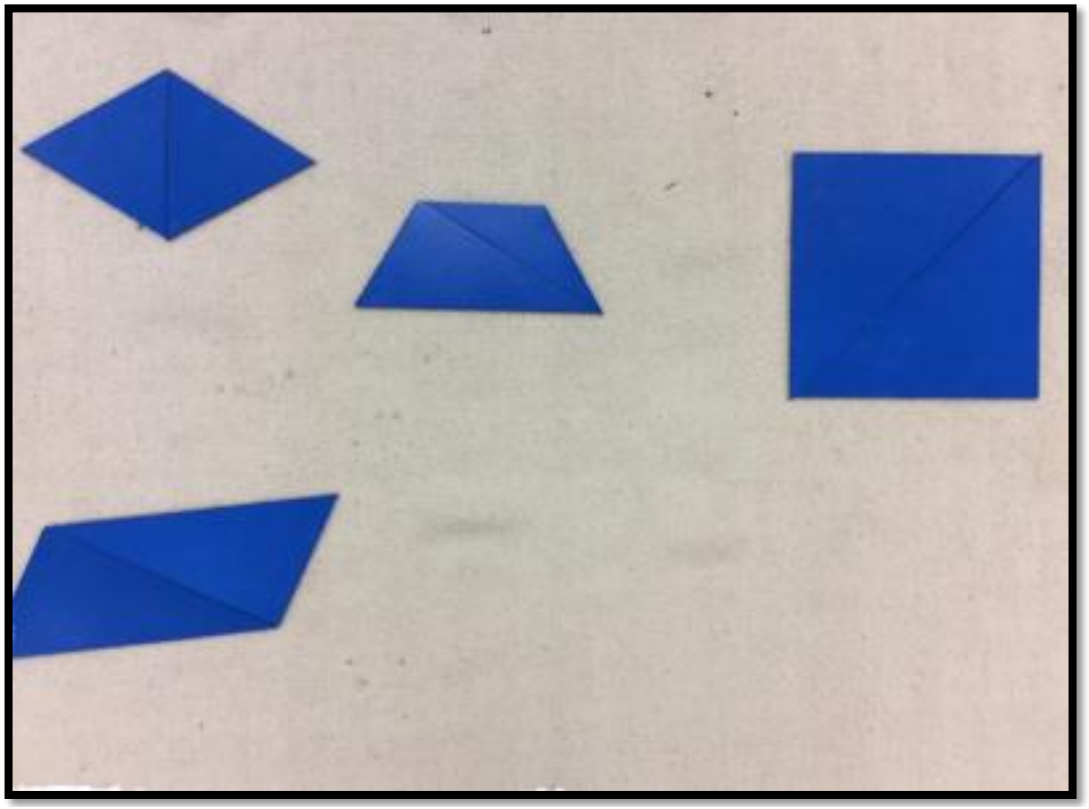
Recording Example of End of the Year Assessment for Mathematics in SPPS



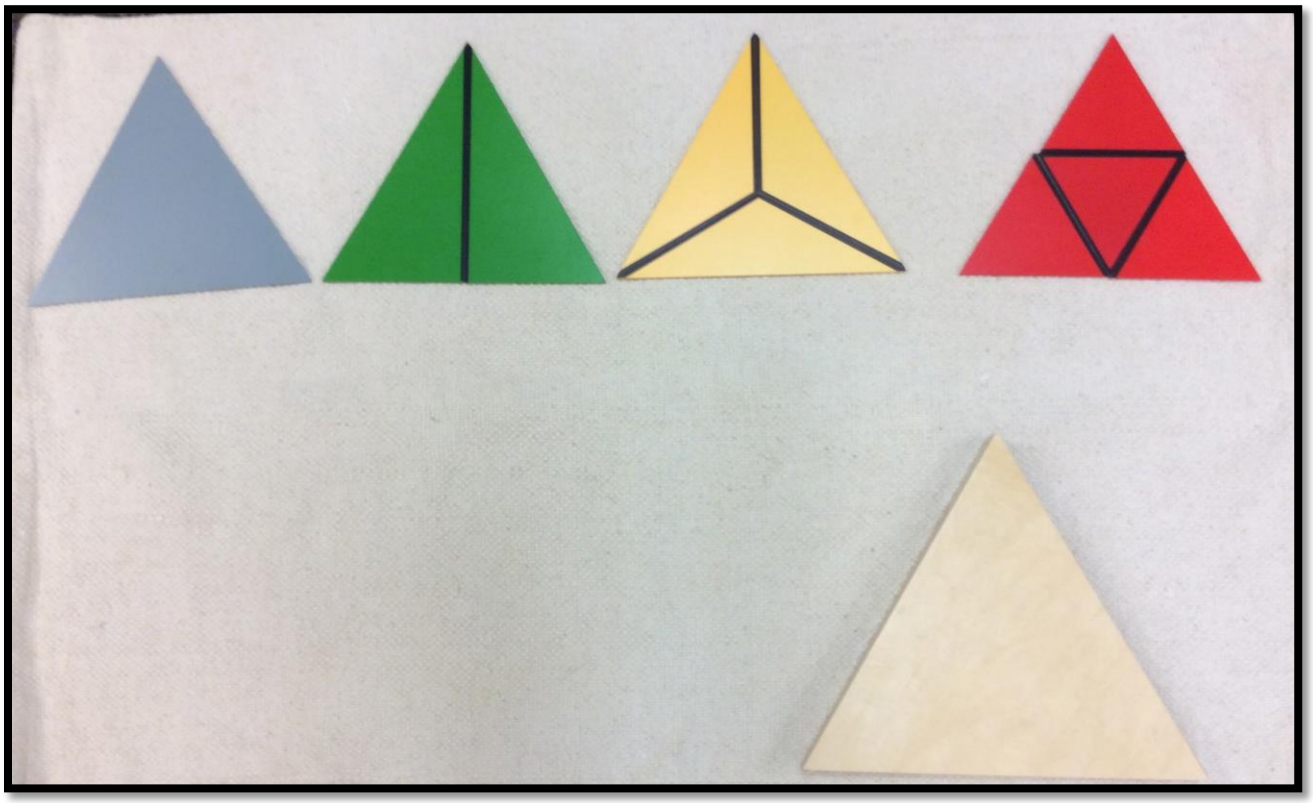
BEGINNING | DEVELOPING | PROFICIENT | EXEMPLARY

K.3.1.1.a I can recognize 2D shapes.		K.3.1.1.b I can recognize 3D shapes.		K.1.1.3.b I can count forward to 20 **without** objects.		K.1.1.2.a I can read numbers from 0 to at least 31.		K.1.1.3.a I can count forward to 20 **with** objects.		K.1.1.1.a I can match a number to a set of objects.		K.2.1.1.d I can complete shrinking patterns.
BASE	EOY	EOY	BASE	EOY	BASE	EOY	BASE	EOY	BASE	EOY		
4	6	4	114	20+	11	31+	6	20	6	31	4	
	5	2		109		31+		20	6	31	1	
4	5	4	115	114	11	31+	6	20	6	31	4	
3	5	4	109	189	11	31+	6	20	6	31	4	
4	6	4	100	110	11	31+	6	20	5	31	3	
1	3	4	12	20+	11	31+	5	20		31	1	
3	6	4	14	100	11	31+	6	20	6	31	3	
3	1	3	6	39	2	15	5	20	6	10	2	
3	6	1	12	29	10	15	5	20	6	17	2	
2	4	4	29	100	11	31+	5	20	6	31	4	
4	6	4	109	109	11	31+	5	20	6	31	2	
3	5	3	13	100	7	22	3	20	0	29	3	
4	4	1	39	120	11	31+	6	20	6	31	3	

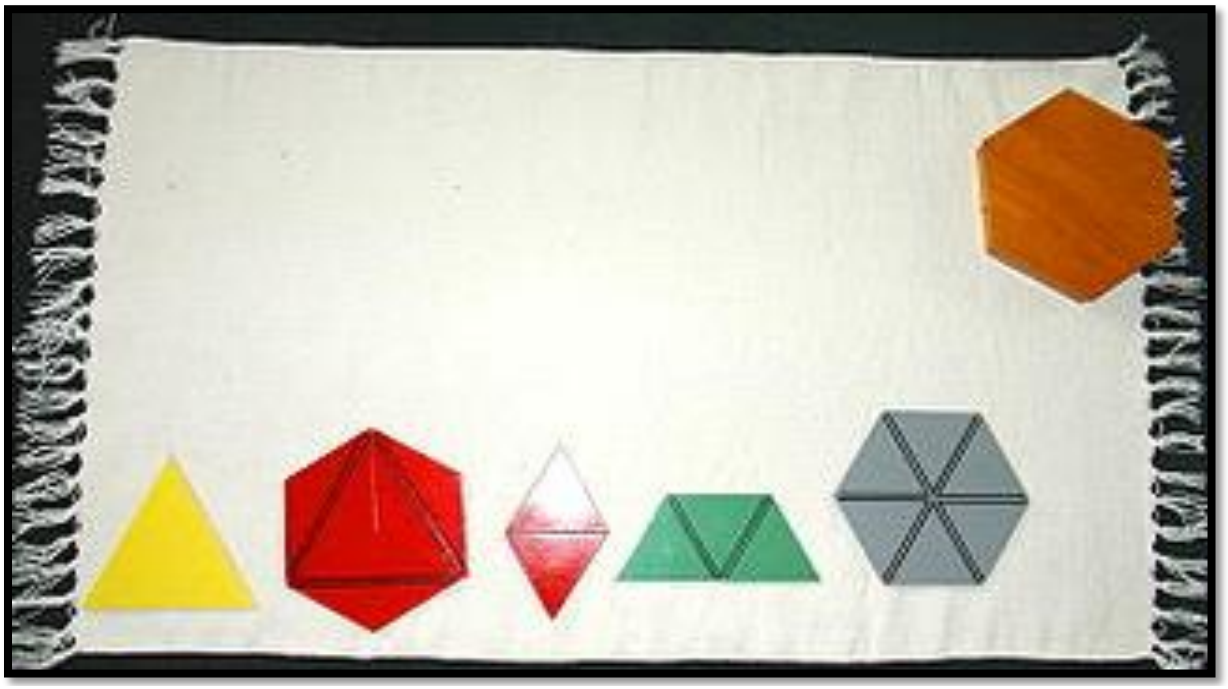
Appendix D
Constructive Triangles



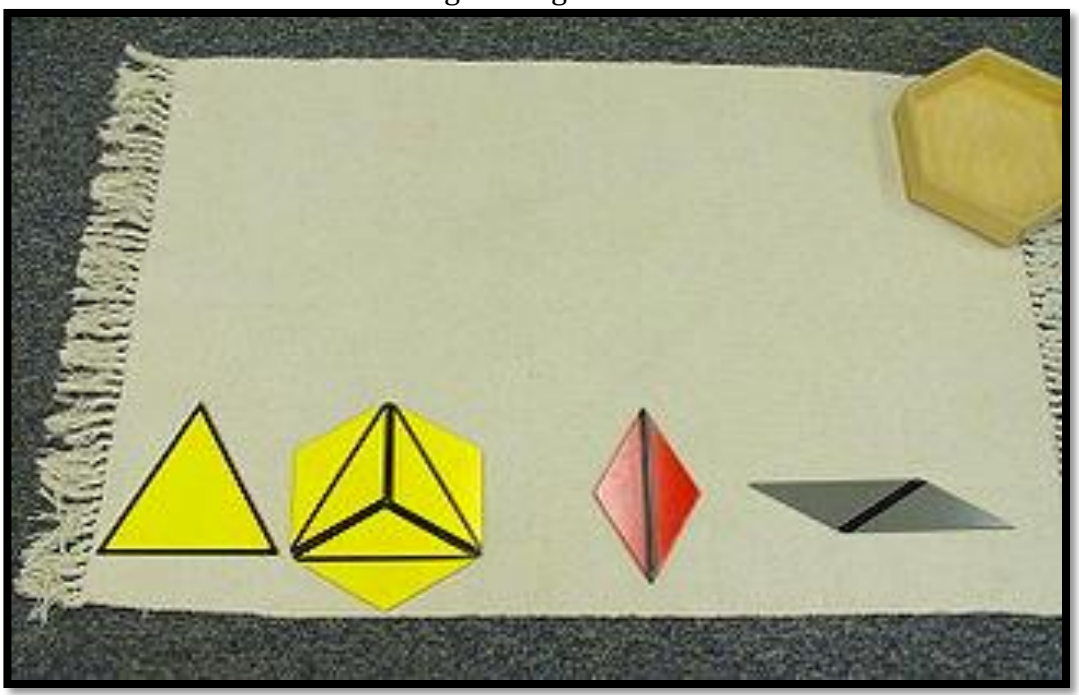
Appendix E
Triangle Box



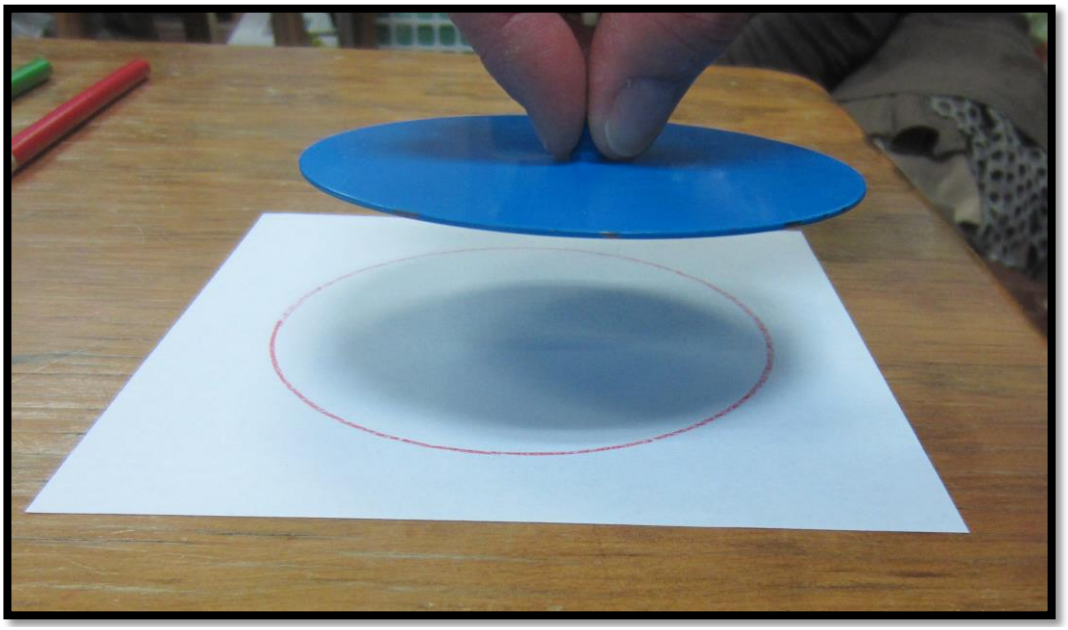
Appendix F
Small Hexagonal Box

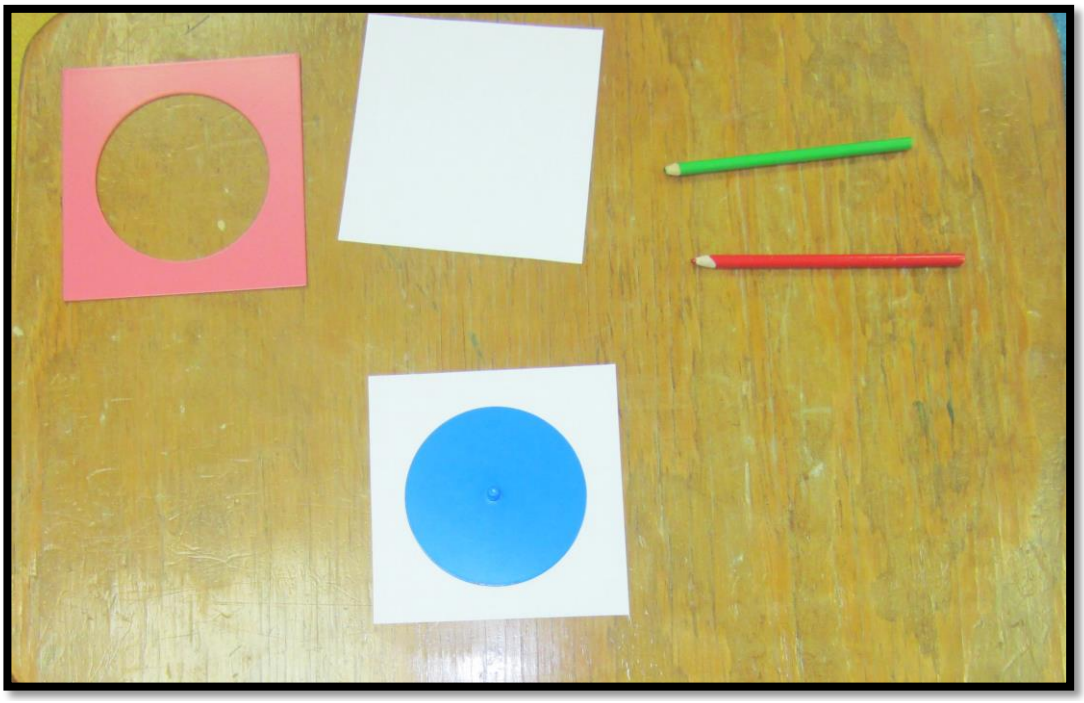


Large Hexagonal Box

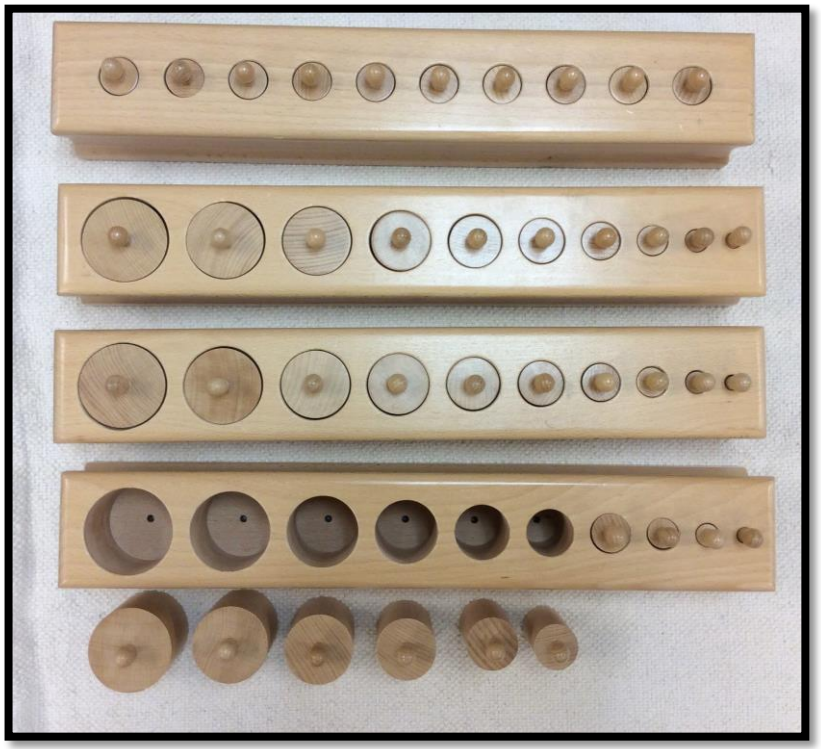


Appendix G
Metal Inset of a Circle

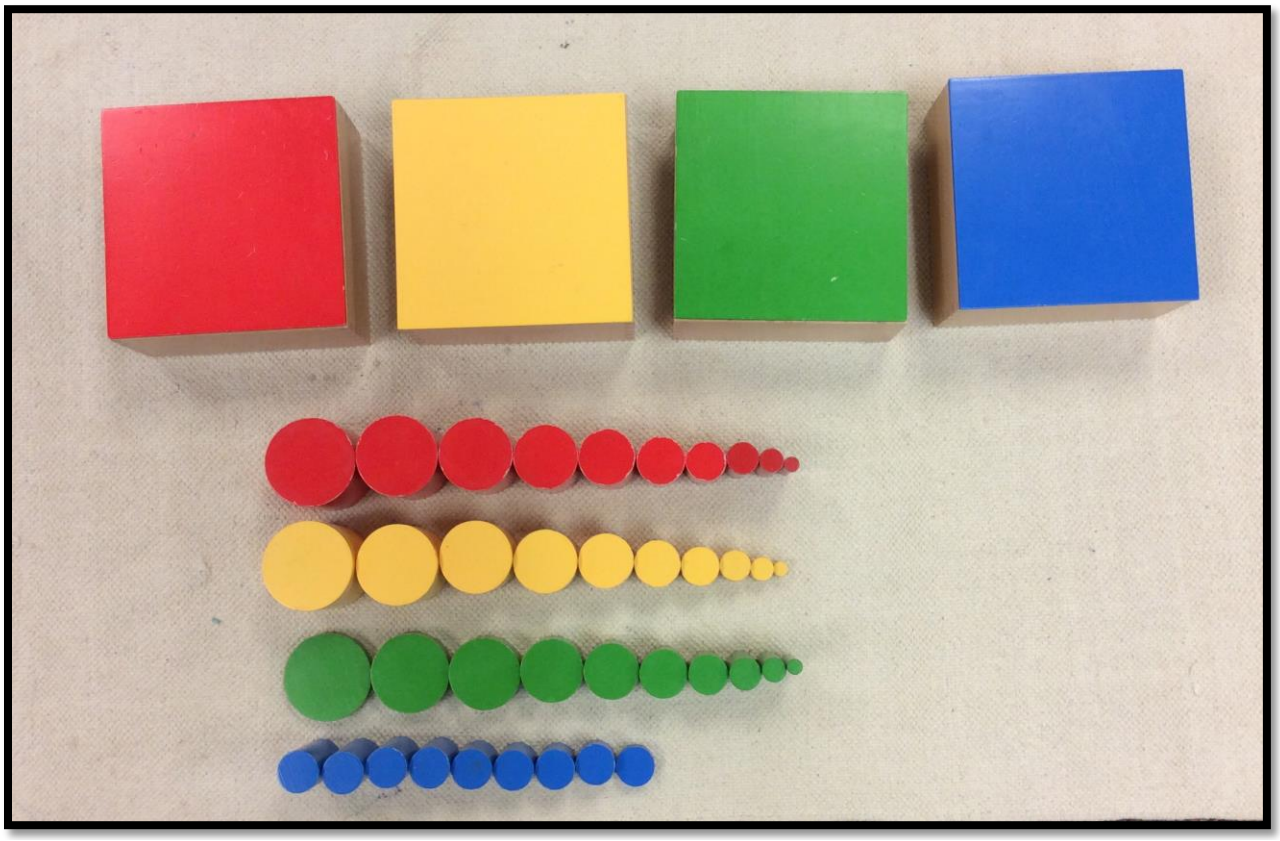




Appendix H
Knobbed Cylinders



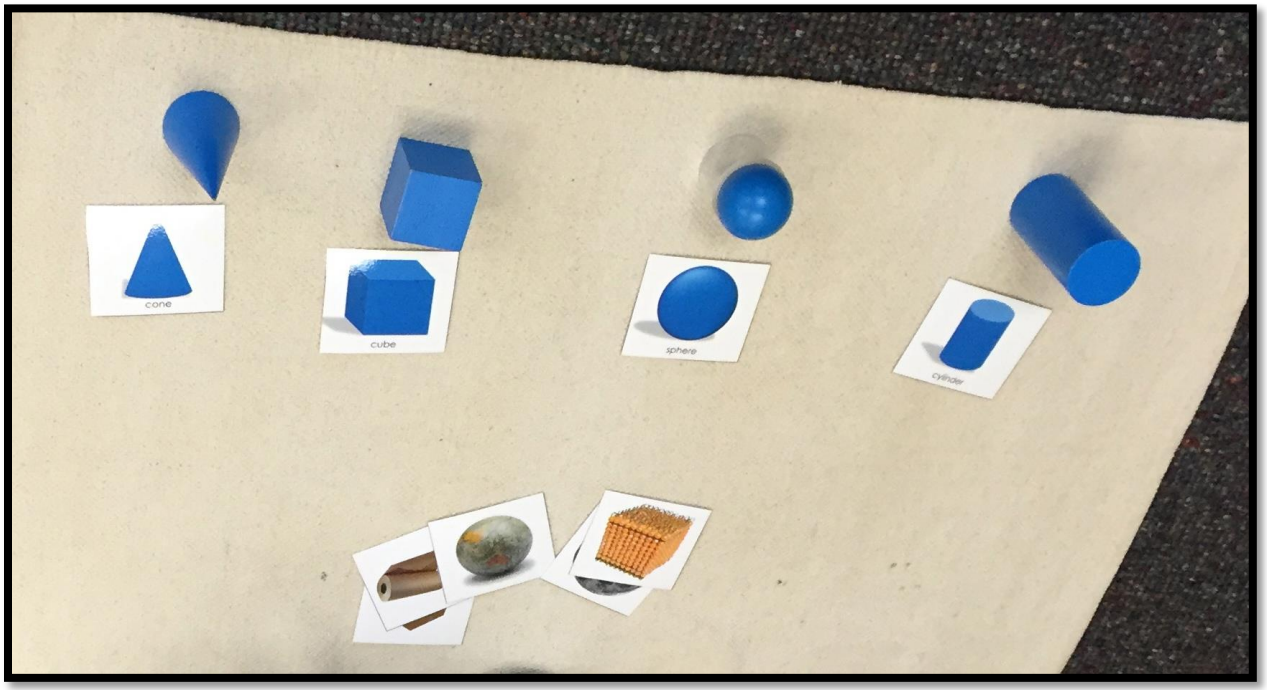
Appendix I
Knobless Cylinders



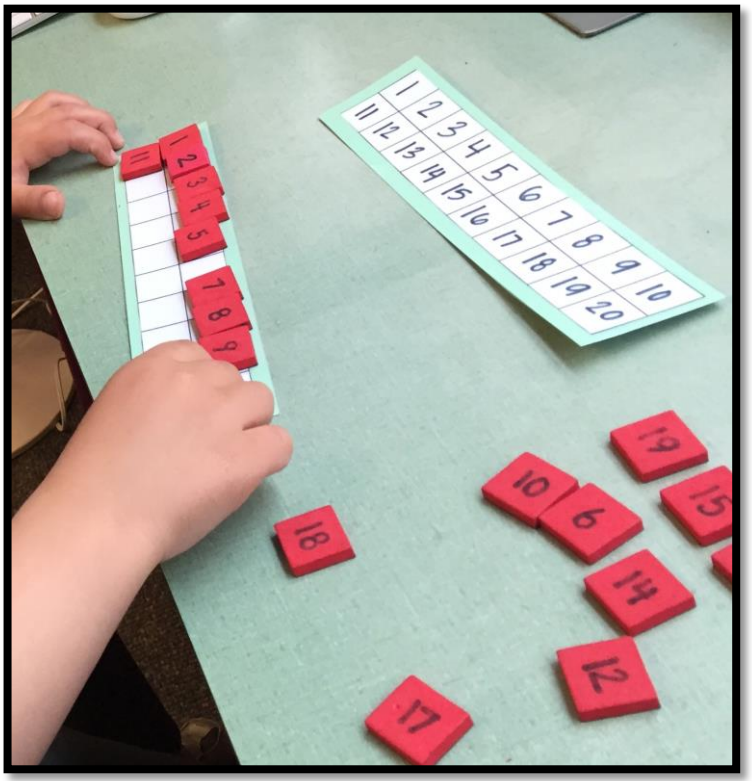
Appendix J
Pink Tower

Appendix K
Brown Stair

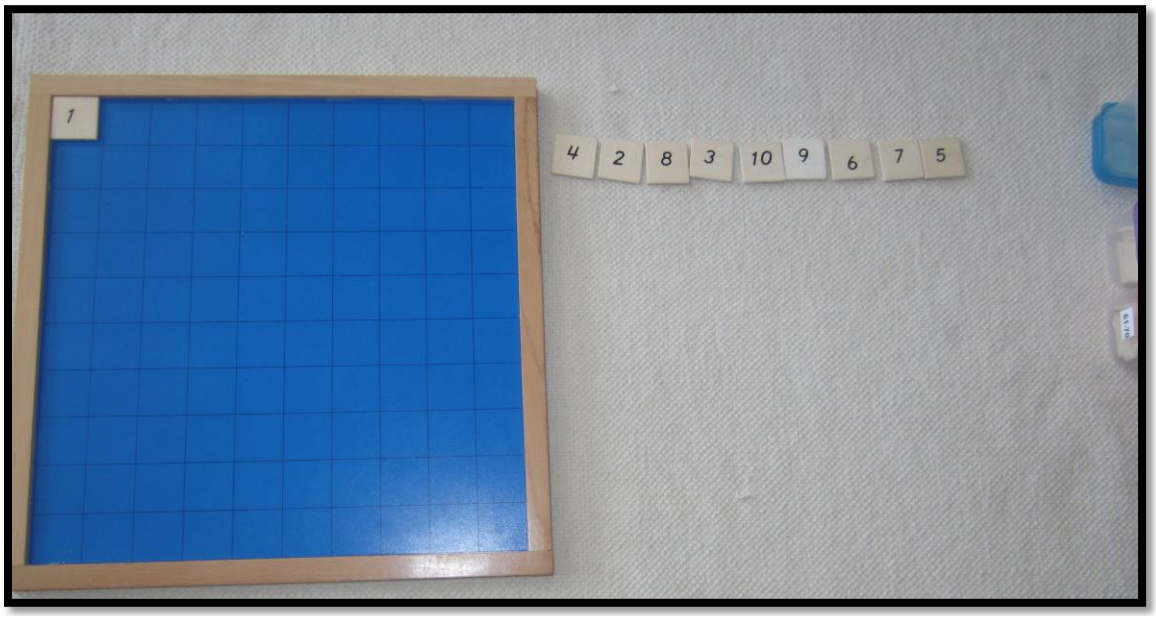
Appendix L
Geometric Solids and Matching Cards



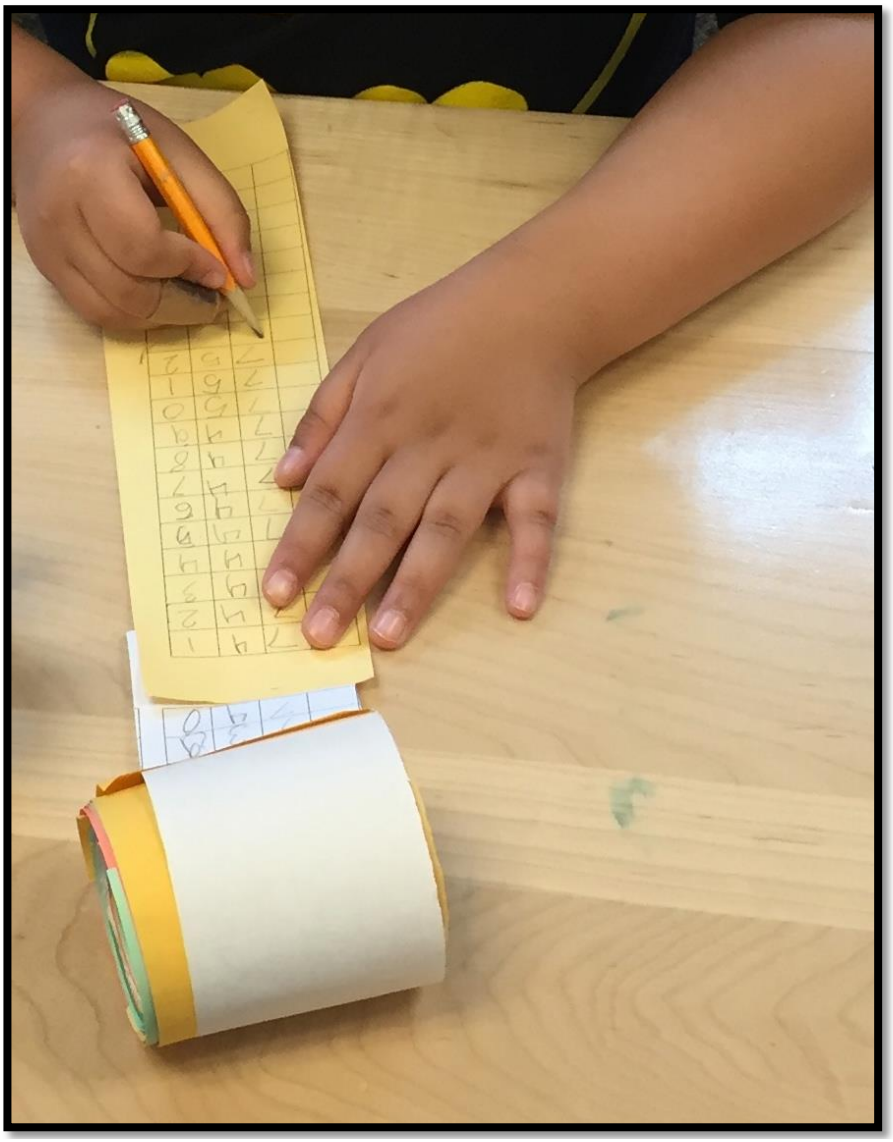
Appendix M
20 Board



Appendix N
100 Board

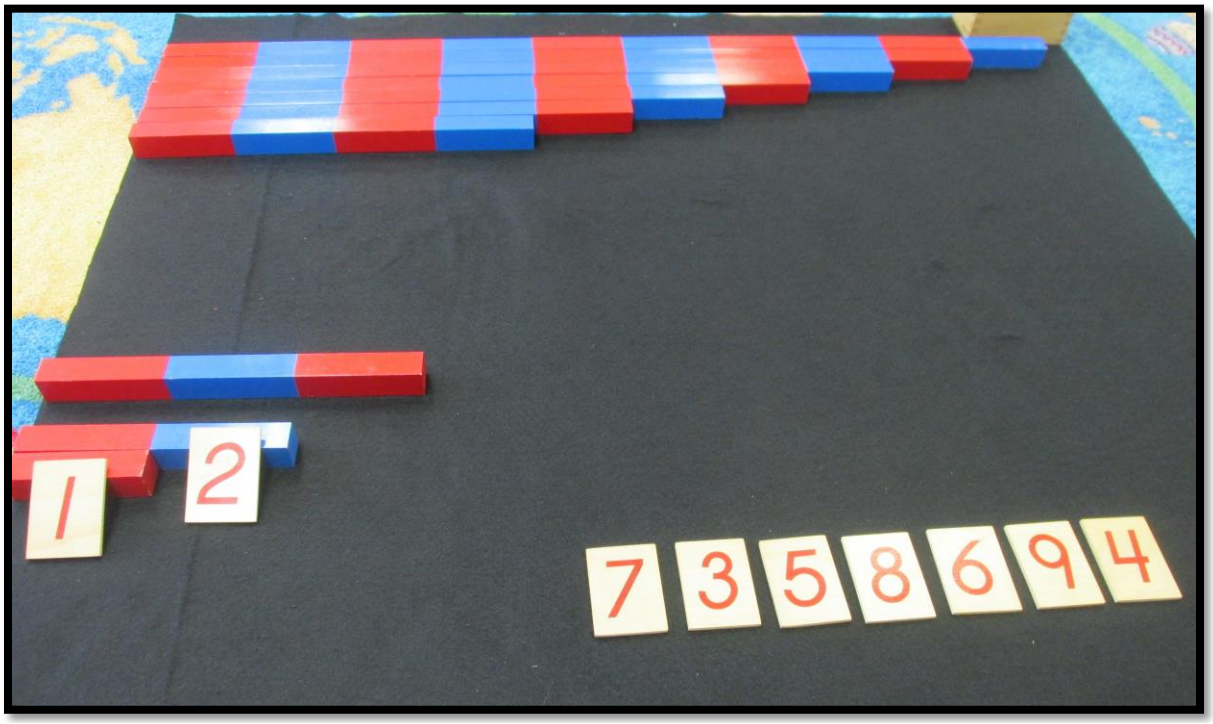


Appendix O
Number Scroll



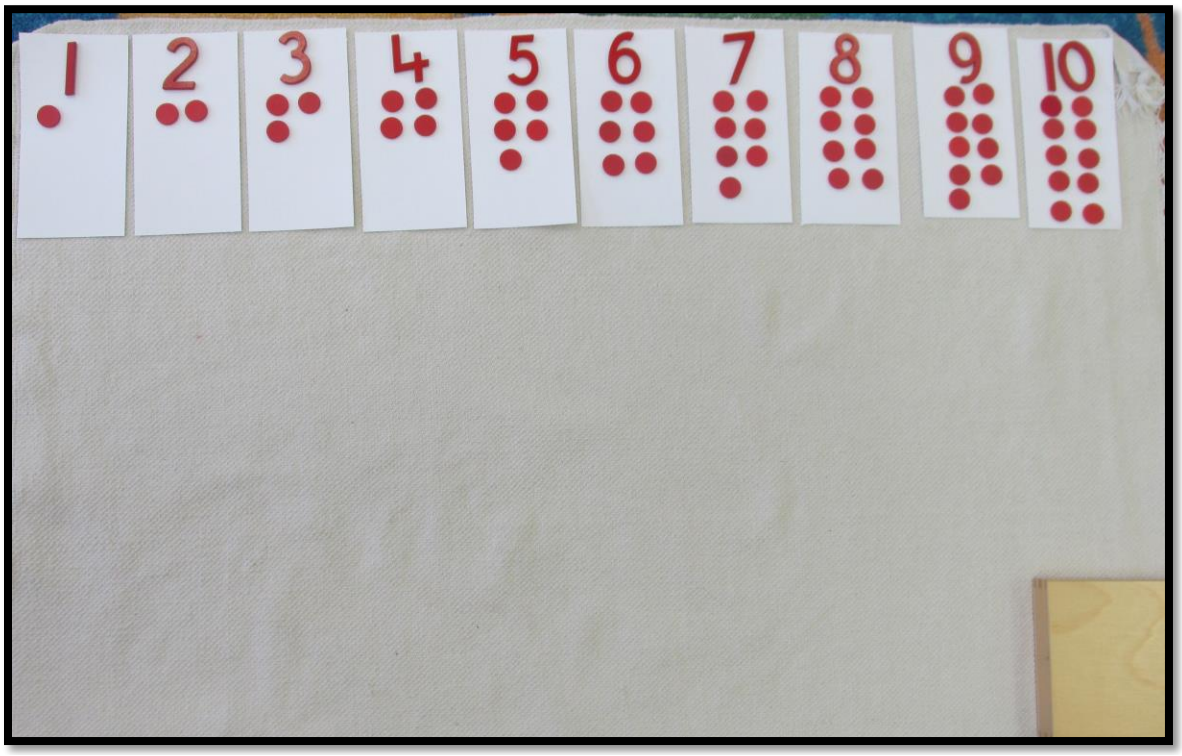
Appendix P
Sandpaper Numerals

Appendix Q
Number Rods and Numerals

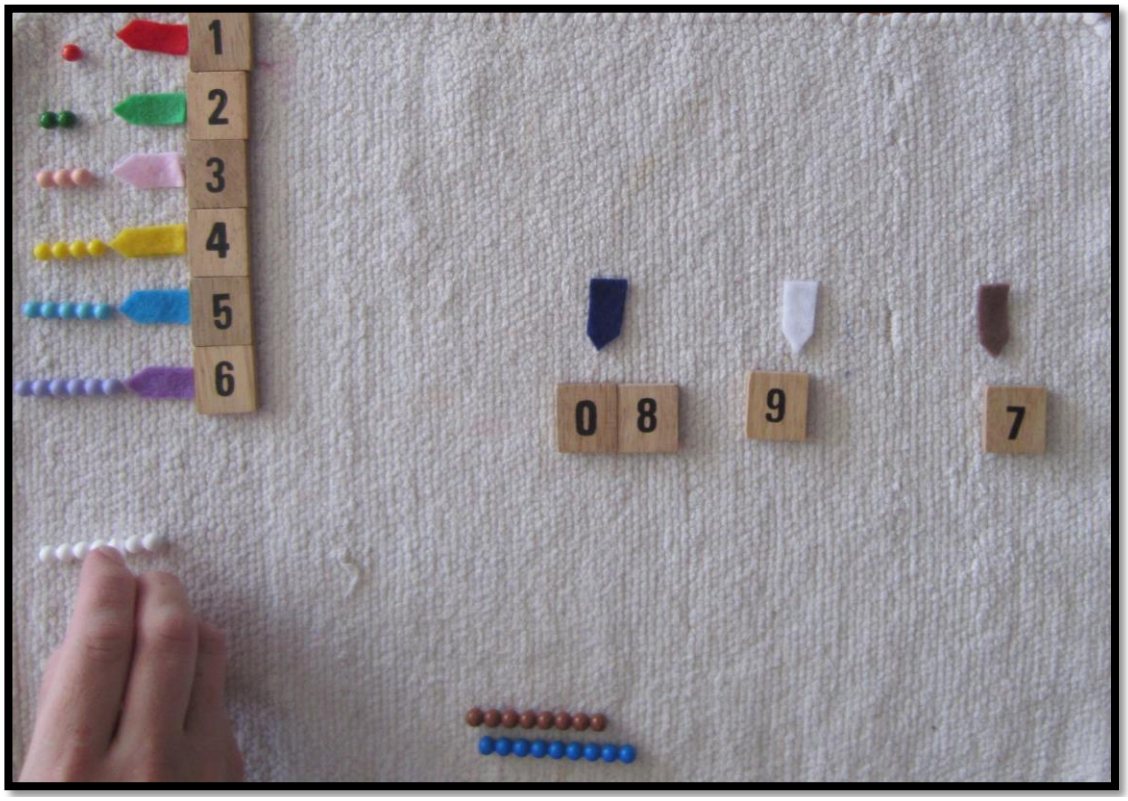


Appendix R
Spindle Box

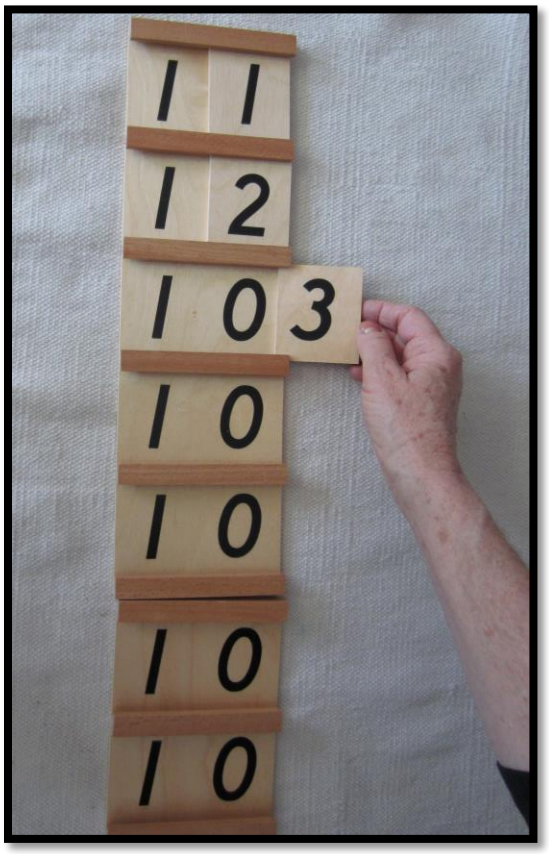
Appedix S
Numerals and Counters

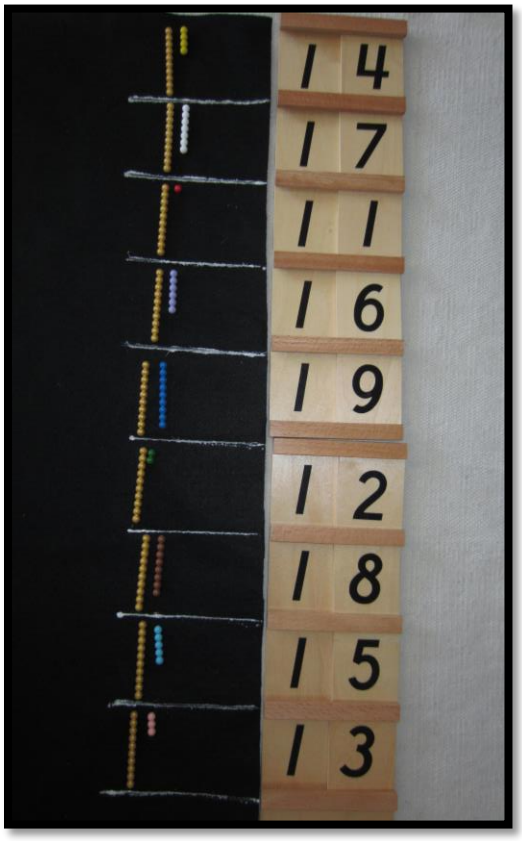


Appendix T
Small Bead Stair



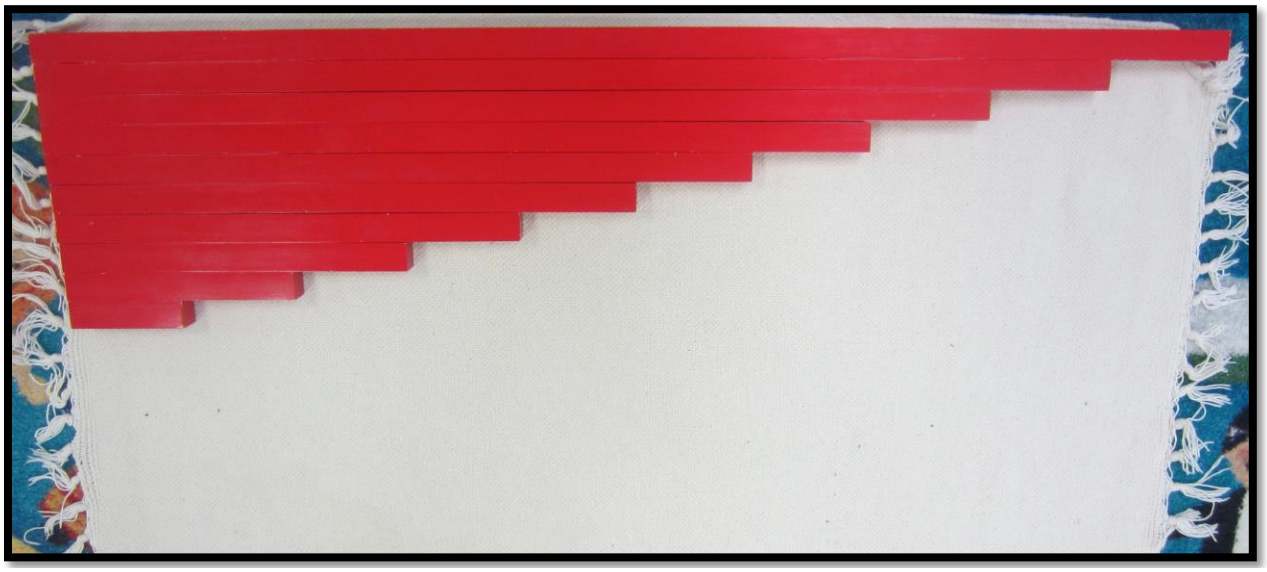
Appendix U
Teen Board





Appendix V
Ten Board

Appendix W
Red Rods



Appendix X
Number Rods