Teaching Measurement in Early Childhood

**Definition of Goals and Project Thesis**

For the first time in the private school that I teach, mathematical expectations have been extended to the youngest classes. The entrance and exit expectations have been made very clear for each grade level, and I have made many changes to the curriculum of my class. I have never taught measurement in a formal sense, and this was first experience with it in my classroom this year. The grade level above mine (Pre-Kindergarten) asked us to hit on certain areas of mathematics that we have not touched on in the past.

This year in my three and four year old class, we will focus specifically on some very important mathematical building blocks that will help my students in the future. One of the most fundamental of these building blocks involves measurement. When we think about measurement, we often just think about feet, inches, and miles, but measurement is so much more than that. It also includes comparing, ordering, lengths, height, weight, volume, and so much more. The first steps are learning the language of measurement and learning how to reason with nonstandard measuring tools. My goal for this project was to find the most developmentally appropriate activities to engage my students in a developmentally appropriate level of mathematical reasoning with measurement concepts.

This subject matter is important to me because I believe that young children CAN learn big mathematical ideas, but as a teacher I have the great challenge of finding activities that introduce the ideas in an appropriate way. People use measurement concepts on a daily basis, but research shows that American students are not getting enough out of what teachers are teaching. Somewhere there is a disconnect between traditional classroom measurement lessons and success in measurement in the real world. In *Math Matters: Grades K-8: Understanding the Math You Teach*, Chapin and Johnson describe an unsettling truth about students in the United States. “In spite of how regularly we use measurement, results of
national and international assessments indicate that U.S. students of all ages are significantly deficient in their knowledge of measurement concepts and skills.”¹

Furthermore, in many cases, students’ experiences in measurement are based solely on finding answers that have no meaning. They are not learning how to reason with measurement. Douglas Clements, in his article *Teaching Length Measurement: Research Challenges*, provides a startling statistic put forth by the National Center for Education Statistics. “Many students use measurement instruments or count units in a rote fashion and apply formulas to attain answers without meaning. Less than 50% of seventh graders can determine the length of a line segment when the beginning of the ruler is not aligned at the beginning of the line segment. In international comparisons, U.S. students’ performance in geometry and measurement is lower than in any other topic.”² My goal in my own classroom was to start my students on the right track.

I wanted to find out what the most appropriate activities are to teach my students the basic building blocks of measurement so that they can learn to reason with the concepts. So I used my research about measurement in early childhood education to motivate the creation of a two-week lesson plan that I enacted in my classroom from November 9th through November 20th. I documented the progress that occurred throughout these two weeks. My goal was to introduce my students to the process of reasoning in measurement, and I found that the activities that we did in the classroom were very fruitful, and my students learned a great deal.

**An Introduction to my Classroom and Students**

My classroom is made up of eight students, and this is the smallest class I have ever had. My students range in age from 3 years, 7 months to 4 years, 3 months. The school is a private, Christian K-8 school located in the Museum District of Houston. All of my students are white and come from affluent families. Our classroom is made up of two tables that seat

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six students each, an art shelf, a book shelf, a manipulatives shelf, two block carts, two ride-on trucks, a puppet theater, a kitchen/home center, a loft and a sensory table (water, deer corn, sand, beans, etc.). It is a very small classroom, but with so few students it does not feel crowded. Normally there are two teachers in the class, but my teaching partner was away on maternity leave during the measurement unit. I had a substitute teacher assisting me during my partner’s maternity leave.

A typical day in my classroom begins at 8:00 A.M. As my students arrive, they find their journals at the tables and practice their writing. When they finish their journals, they sit at the tables with a book or a puzzle until it is time for circle. Circle time begins with a discussion about the calendar and the weather every day. Our pre-school curriculum is unit based, so we have a new unit every one to two weeks that all of our activities revolve around. During the measurement unit, we were involved in our Fall Harvest/Farmer’s Market and Thanksgiving units. After we discuss our topic of the day, we always end circle with a book or an activity. Circle typically lasts for about 25 minutes. After circle, the students engage in center time until we go to our special classes. During center time, the students have free reign of the myriad activities we have in our classroom. While they are playing, one teacher calls one student at a time to perform an art project. This is the one-on-one time that we have with the students every day. We have a special class every day (motor skills/PE, music, library, or chapel), and when we get back from specials we clean up the classroom, wash hands, and have snack. After snack, we have a bathroom break and then individual “reading” time during which students must find a book and look at it quietly. We then go to the playground until shortly before dismissal. The time between playground and dismissal is spent on the alphabet, letter of the week, reading a story, and singing a motion song. Dismissal is at 12:00 P.M.

We have a very short school day because our students go home at noon, so I had the challenge of fitting all of the activities into our busy school day. Plus, any extra math, science, and literacy activities that we want to accomplish have to be introduced during center time. It is important for our students to have time for free play, as we usually try to allow for as much play time as academic time. This provided me with an added challenge as I created the lesson plans for this unit.
The greatest challenges that I faced in planning this unit included behavioral issues, possible confusion surrounding the concepts, a lack of interest, a teaching partner who was away on maternity leave, and a short amount of time for enacting this unit. So, I had to make sure the activities were appropriate, interesting, engaging, time-efficient, and easy enough to virtually enact on my own. Marilyn Burns, in her article *10 Big Math Ideas*, helped me to gain some perspective as I planned this unit. She wrote, “Don’t expect all children to learn everything at the same time, and don’t expect all children to get the same message from every lesson.” This helped me to focus on the lessons themselves, and not necessarily the results. Her article explains that “success come from understanding.” With this in mind, I was able to focus on planning activities that would help my students truly understand measurement.

**Background/Research/Literary Review**

In order to go about planning my lessons, I researched multiple different things. First, I took into account what mathematical standards are in place. I found out more about how young children learn about measurement and number sense. I learned more about what kinds of activities are most appropriate for young children and what types of measuring I should introduce. I learned more about how to incorporate math concepts into all areas of our curriculum, and I examined the research of others about how much is too much to introduce to young children.

My first task was to look at what standards were in place to guide my planning. If there were certain topics that I needed to give more attention to, then I needed to know it. I looked first at the grade level math standards that my school has put forth. They state that students should exit Beta year (my grade level) and enter Pre-kindergarten with an “understanding of non-standard measurement.” Also, The National Council of Teachers of Mathematics standards for grades K–4 put a great deal of focus on what children should understand. “In grades K–4, the mathematics curriculum should include measurement so that students can: 1. Understand the attributes of length, capacity, weight, mass, area, volume,
time, temperature, and angle; 2. Develop the process of measuring and concepts related to units of measurement; 3. Make and use estimates of measurement; 4. Make and use measurements in problem and everyday situations.”⁶ They also state that instruction at the K-4 level should emphasize “the importance of establishing a firm foundation in the basic underlying concepts and skills of measurement.”⁷ Though these standards are meant to apply to students older than my own, I believe that they could apply to my students on a more basic level. Therefore, I took them into account when planning my lessons.

Young children, especially children under 5, learn measurement in very different ways than older children because of what they can developmentally understand. Jean Piaget’s theory of conservation says that “a physical quantity does not change during certain transformations.” Piaget “and his collaborators found that children younger than 5 years judge length in terms of end points only. For example, children judge a line segment and a bent path with the same end points to have the same length.”⁸ This told me a lot about how my students would be viewing length activities, a little about the basis of their knowledge, and what their developmental capacity might be. This was very helpful as I dove deeper into the research surrounding how young children learn measurement.

When learning about measurement, a young child’s number sense certainly comes into play. Bernice Kastner wrote about the role of number sense in young children’s measurement activities. She explains that “real-world applications can make a significant contribution to the development of number sense in elementary school students, since they offer an opportunity to test numbers that result from computational processes against observations.”⁹ Though she wrote about elementary age students, this is also true for early childhood students. Activities that mirror the realities of three and four year old students provide an opportunity to make concrete connections and promote greater understanding.

John Van de Walle, author of Elementary and Middle School Mathematics: Teaching

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⁷ NCTM 51.
⁸ Clements 5.
Developmentally, agrees. In his chapter on the development of measurement concepts, he writes, “Early measurement activities are a very meaningful context for counting. Measurement of important objects in the familiar environment connects ideas of number to the real world, enhancing number sense.”  

If activities in mathematics are based too much in the textbook or lack any relation to a student’s reality, then Kastner believes they are missing out. Students, she explains, might be led “to believe that school work in mathematics does not relate to real experience.” This, then, “hinders the development of number sense.”

There are quite a few steps a student has to master when learning how to measure. Van de Walle lays them out in his chapter on developing measurement concepts. “To measure something, one must perform three steps: 1. Decide on the attribute to be measured. 2. Select a unit that has that attribute. 3. Compare units, by filling, covering, matching, or some other method, with the attribute of the object being measured.”

This is a lot to remember for young child, but these steps are extremely important because they are the foundation of measurement. I took these steps into account as I ordered and planned the concepts I would introduce to my students.

I next needed to determine how I should go about teaching measurement to my young students. I needed to decide if I should teach standard measurement, non-standard measurement, or both. Several researchers have addressed this question in regards to young children, and I found that most researchers agree that limiting the lessons to non-standard measurement is the most appropriate for children under 5. Van de Walle cited the NCTM Principles and Standards when he wrote, “students should have ample opportunities to use informal units and similar meaningful experiences with measurement – regardless of grade level – before focusing on tools and formulas.” Chapin and Johnson agree. In their chapter on measurement, they argue that non-standard measurement should always come first. “Because there are many standard units and many relationships among them, it takes a

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11 Kastner.
12 Van de Walle 376.
13 Van de Walle 378.
number of years of students to gain the necessary skills to use measurement tools carefully and accurately and to apply measurement concepts meaningfully.”

Non-standard measurement, as described by Bernice Kastner, is the use of “blocks, paper clips, coffee-stirring sticks, or other common objects.” These items are important to use when describing the length of something because it improves the student’s understanding of comparisons. Kastner explains that it is important to “de-emphasize the use of standard units until you are satisfied that the underlying principles have been grasped by the students.” The NCTM standards reiterate this idea. The standards state, “Premature use of instruments or formulas leaves children without the understanding necessary for solving measurement problems.”

Mary Baratta-Lorton wrote about using this approach when introducing measurement to her young students. In her book, Mathematics Their Way, she suggests focusing lessons on engaging, meaningful, real-world experiences. Measurement, she says, “should begin with ‘Which one is [bigger/taller/longer] than the other?’ and should grow into ‘How much more?’” She believes that “at this early state numbers interfere rather than enhance the development of the concept…Using standard measurements of centimeters or inches is a much later step and should only be used after the children have had an opportunity to create their own standard and fully explore the idea of measurement.” Moreover, Baratta-Lorton’s methods help students to make comparisons between real-world items that they can later apply numbers to. “The skill of making comparisons,” she says, “contributes an important step to the child’s growing mathematical understanding. Children begin by comparing familiar objects, as numbers are too abstract. Eventually they will be able to apply this knowledge to the relationship between one number and another.” This felt very applicable.

14 Chapin and Johnson 272.
15 Kastner.
16 Kastner
17 NCTM 51.
19 Barrata-Lorton 139.
to my classroom because my students have a lot of practice with making comparisons. This felt like a very appropriate place to start with the introduction of measurement.

With these ideas in mind, I set out to create a lesson plan that was developmentally and academically appropriate for my young students. What are the most appropriate activities for young children to learn non-standard measurement concepts? The authors of *Crisis in the Kindergarten: Why Children Need to Play in School* (Miller and Almon 2009) explain that young children need to learn through touch and exploration. “Children now spend far more time being taught and tested on literacy and math skills than they do learning through play and exploration, exercising their bodies, and using their imaginations.”21 In regards to measurement activities, Van de Walle explains that there is “too much reliance on pictures and worksheets rather than hands-on experiences and a focus on skills with less attention to the concepts of measurement.”22 Chapin and Johnson agree that “measurement should definitely be taught ‘hands on.’”23

**The Lesson Plans (See Appendix B for the full lesson plans)**

As I went about creating the lesson plans, I had a lot to think about. Step 1 in laying out the plans for the ten days of lessons was deciding what kind of measuring I planned to teach. I knew that length was going to be the most attainable concept for my students because there are so many ways to learn about and practice length measurement. I also intended to teach height, volume, weight, distance, time, and weather. In all of the research that I did, these were the most commonly referenced types of measurement. Monetary measurement was also mentioned often, but I decided to leave money out of this unit because of time constraints and age appropriateness.

In an early childhood classroom, mathematics can and should be incorporated into nearly every aspect of the daily routine. The NCTM standards suggest that measurement concepts and skills “should be integrated through mathematics and other curriculum areas. Not only will this enhance other topics but it will also give children opportunities to develop

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21 Edward Miller and Joan Almon, “Crisis in the Kindergarten: Why Children Need to Play in School,” *The Education Digest*, Ann Arbor: Vol. 75, Iss. 1 (Sept., 2009), pg 42.
22 Van de Walle 374.
23 Chapin and Johnson 271.
and retain measurement concepts and skills.” With this in mind, I started to think of all of the ways that I could incorporate measurement into our morning. By incorporating these ideas, Marilyn Burns explains that I would then be providing a real-world context for our math lessons. “Real world contexts can give students access to otherwise abstract mathematical ideas. Contexts stimulate student interest and provide a purpose for learning.”

Through the use of guiding questions, discussions, exploration, imaginative play, storytelling, literature, art, movement, cooking, and guided play, I was pretty confident that I could incorporate measurement into almost every aspect of our day.

I began by developing the guiding questions for each day. I had to fit our measurement unit into our Fall Harvest/Farmer’s Market and Thanksgiving units, so I had a bit of a challenge on my hands. After I had decided what we would study each day based on our theme, I decided what type of measurement we would explore each day. I planned to spend one day on an introduction to measurement, four days on length, two days on height, two days on volume, one day on weight, and two days on an overview. Some of these lessons overlapped on certain days. Volume was technically studied on eight of the ten days because as a part of the measurement unit I included eight days of cooking, and on each of these days we had a conversation about volume as we measured out our ingredients.

During our morning circle time, I led our discussion of the calendar, the weather, and our guiding question for the day. We always began with our “Days of the Week” song, our “Months of the Year” song, and discussed the day’s date. This was our daily discussion about the measurement of time. We then spent some time talking about the general temperature (hot, warm, cool, cold) and patterns of weather throughout our week. This was our daily discussion about the measurement of weather. During our discussion of the thematic topic, I found fun ways of incorporating measurement activities into our lessons. Each day we had a circle time measurement activity, and I found this was a good time to demonstrate proper procedural technique. The authors of “Gummy Worm Measurements” reiterate this idea. “An important component of measurement success is to discuss and demonstrate with students how to measure using proper techniques (e.g. no gaps between worms, no overlaps, no parts

24 NCTM 51.
25 Burns 17.
hanging off an edge, no stretching of the gummy worm).”

As I measured each item or conducted an experiment during circle, I found it useful to talk through each step so to enhance their understanding. I did not want them to simply emulate what I was doing, but I instead wanted them to comprehend why I was doing what I was doing and learn the language that I was introducing.

I next decided what our art projects would be for each day. Throughout the entire year, we do an art project every day to enhance the students’ fine motor skills, so I needed to come up with projects that would go along with our theme as well as incorporate measurement. Unfortunately, I was not successful in accomplishing this on every day, but we did do a project on most of the days.

My final step in creating my lessons was determining what manipulatives I would put out on our shelves as well as what activities we would do as a large group and in small groups. Chapin and Johnson believe that “measurement should definitely be taught ‘hands on,’” and I completely agree with them. On our manipulatives shelf, in order to provide the students with hands-on materials, I placed several items that were intended to promote their exploration. Miller and Almon believe “teachers need to understand the ways in which child-initiated play, when combined with playful, focused learning, leads to lifelong benefits in ways that didactic drills, standardized tests, and scripted teaching do not.” This was highly motivating for me as I tried to find the right manipulative items to make available to the students. On our shelf, I placed a plastic marble run, a scale, a math measurement game, a basket of unit cubes, play dough and tools, a flower matching game, a tub of cars and trucks, a lacing game, a sorting/ordering game, wooden blocks, a story basket (Inch by Inch by Leo Lionni), and a water station with several different sized water vessels. Not all of these items were obviously intended to promote the practice of measuring, but some were used in creative ways as the students engaged in non-standard measurement.


27 Chapin and Johnson 271.
28 Miller and Almon 44.
In our school, we base most of our lessons on literature and play, and a significant amount of research supports this practice. Our lessons are usually based around a particularly powerful book or a particular book is integrated into our lessons. Marilyn Burns, author of *Ten Big Math Ideas*, and Lisa Von Drasek, author of *The “Wow” Factor*, both agree that literature and mathematics can and should intermingle in the classroom. In my classroom, we use imaginary play and storytelling to capture the interests of the students. Burns believes that this is a good starting point for math lessons. “Contexts can also be created from imaginary situations, and children’s books are ideal starting points for classroom math lessons.”²⁹ This is an interesting link to activities that we already do in the classroom.

Von Drasek explains how important children’s books are in the process of capturing the interest of the students. “Evidence shows that teaching math through children’s books motivates children to learn math in exciting new ways; encourages students to think and reason mathematically and builds students’ appreciation for math and literature.”³⁰ She quotes David Whitin when she urges that educators be careful not to choose a book just for its ability to fit into a math lesson. “Any book that has some intriguing mathematical possibilities must be judged, first and foremost, as a worthy piece of literature. It must be marked by an engaging story line, beautiful language and a sense of wonder about the world.”³¹

In their article, “Making informed choices: Selecting children’s trade books for mathematics instruction,” Hellwig, Monroe, and Jacobs explain how important books are for making connections between the classroom and the outside world. Trade books, or books other than textbooks, “allow students to interact with mathematics in context, helping them draw meaningful connections between experiences in the classroom and life outside the classroom…They provide appealing settings that show students how mathematics exists in our world.” They also “give students the opportunity to develop language skills as they develop mathematical skills.” They go on to explain how important books are in math lessons because they enhance a student’s vocabulary and knowledge of mathematical

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²⁹ Burns 18.


³¹ Von Drasek 62.
language. “Many researchers assert the value of using trade books to encourage students to reason and communicate mathematics.”

Assessment of Data

My goal for this project was to help my students engage in reasoning with measurement concepts. Teaching the kids the concepts and language was one thing, but ensuring that they were engaging in reasoning was quite another. Reasoning means many different things to different people, but I believe mathematical reasoning to be the collective development of a mathematical language and ideas, the building of an understanding of mathematical concepts as well as procedures, and the ability to manipulate ideas to solve problems and justify mathematical truths. Before I began the project, I set out some goals that I thought would show me that my students were learning to reason with measurement concepts. First, I expected that they would be able to understand and use the basic language of measurement. Second, I wanted them to be able to use the basic principles of measurement when solving a problem. Third, I wanted them to be able to build an argument to support their ideas about measurement.

My experience as a teacher and the research that I did confirmed my belief that observation is the most appropriate way to assess students at the age level that I teach. Miller and Almon believe that proper assessment techniques are extremely important. “While some testing of children under age eight may be useful for screening, it is a highly unreliable method for assessing individual children. Observational and curriculum-embedded performance assessments should be used instead.”32 Even though I spent every day observing my students’ progress in this unit, I used activities that would help me to know whether they were building an understanding of the concepts of measurement. The first week’s activity was a large sheet of paper with three different sized lines on it. I called the students one at a time to come over and work with me on some length measuring. I asked the students to use three different materials (gummy worms, unit cubes, and plastic dog bones) to measure the lines. As they worked, I conversed with them about what they were doing and how they were doing it, as well as watching their techniques. I was observing to see how well they were

32 article 14, page 43
using measurement language, how well they were exhibiting their knowledge of length measurement, as well as listening to their reasoning as they performed this task. (My conversation with one student is included in Appendix C.) This task was extremely interesting because I was able to see how our activities up to this point had affected the students’ knowledge of measurement.

During the last week of the project, I started our school day with a vast array of measurement activities. The purpose of this was to give the students the opportunity to show me what they knew and could do on their own, while still using the opportunity to converse with their classmates. On the two large tables, I set up eight measuring activities. These included a bowl of water with different sized vessels, a measurement game, the Inch by Inch story basket, a shoe box with a large number of unit cubes in it, a sorting/sixing game, and a scale with several small objects. I did not give the students any instructions, but instead listened to see how they were interpreting these activities as well as what kinds of conversations they were having with their classmates. I was very impressed to see and hear so many rational and interesting discussions going on in the classroom. I heard students debating about the best way to use the scale, talking about how tall or long things were in regards to unit cubes, and explaining to each other why we always put the unit cubes one after the other. I was very pleased to hear how much they had learned about measurement, and how, even at a young age, they were showing me that they were able to reason with measurement concepts.

At the end of the unit, I used a dictation activity to assess their understanding. As a part of our routine classroom assessments, we use the practices set forth by the Rice Literacy and Culture Project, a program based out of Rice University.\(^{33}\) As a part of the program, storytelling, dictation, and dramatization are an integral part of allowing students to take ownership of concepts in our curriculum. Every two weeks, we sit down with the students, and we ask them to give us one sentence of “Daily News.” The students know that they will only be able to tell us one sentence, so they each spend some time thinking about what they really want to say. This helps them learn how to summarize their thoughts. At the end of this

\(^{33}\) http://centerforeducation.rice.edu/SLC/index.html
unit, I asked each student to tell me one special sentence about measurement. Each student took the time to think about it, and then I wrote down exactly what they told me. Their answers did not always reflect how well they understood the material, but they did give me some insight about how their knowledge of measurement language had developed. (Their responses are listed in Appendix A.)

In order to determine that I had met my goals for this unit, I developed a numerical system that helped me to determine whether or not my students had made any progress. My purpose for doing this was to ensure that I could monitor the development of my students. As I observed the kids with this numerical system in mind, I frequently reassessed it to make sure that my expectations were developmentally appropriate for these young children.

Students who I considered to be on the first level were able to recognize the basic language of measurement, but they were not able to apply the basic principles or engage in mathematical reasoning. Students who were on the second level had a basic knowledge of the language of measurement, but they could not apply the principles or engage in reasoning. Students I considered to be on the third level understood the basic language of measurement, were able to apply the basic principles of measurement, but were not able to engage in reasoning. And students on the fourth level understood the basic language of measurement, applied the basic principles of measurement, and were able to engage in reasoning.

Not every student started at the same level, but I expected to see improvement from the beginning of the unit to the end. Four students started on the third level, two students started on the second level, and two students started on the first level. (See Appendix A for all students’ progress from beginning to end.) Fortunately, by the end of the unit, I saw advancement in all eight of my students. Five of my students ended the unit on the fourth level. Though my system is not scientific and is only based on observation, I did find it useful in analyzing the observational data that I collected throughout the course of this unit on measurement.

Discussion

There were several limitations to my study. First, I was disappointed to find that minimal research has been conducted on the introduction of measurement concepts to
children in early childhood programs. Most research conducted applies to children in kindergarten and older, and very little applies to children five and younger. My students are three turning four, so they are not quite ready for many of the activities and principles put forward by the journal articles and books that I read. Many of the articles and books that I read also do not reflect the developmental level of my students. This was a big challenge for me because I wanted to base our classroom activities on documented research. But when I had a hard time finding applicable data, I used the next best thing. I went to many of my colleagues who teach in our early childhood department, and I asked them for advice about activities that help children learn the basic language and concepts of measurement. Where the research lacked, personal advice filled in. In addition, I spoke with the kindergarten teachers and learned the language that they introduce to their students so that I could be sure to provide my students with the most appropriate terms. I did not want my students to learn one term only to get to Kindergarten and have to learn another. A common language amongst math students and teachers is incredibly important.

Second, during my research, I found quite a few books that were appropriate for the lessons that we were doing, and my students respond best to books and stories. They are able to take ownership over the ideas and manipulate stories to apply to their own lives. Unfortunately, I was only successful in locating the small number of books that I used during the course of the unit. I checked my school library as well as the Houston Public Library system for the rest of the books, but I was not able to find them.

Third, I wish I had been a little bit more adventurous with the materials that I provided for my students to work with. When I was doing my research, I came across two articles that went against the grain as far as introducing the main ideas of measurement to young children. In two articles, *Teaching Length Measurement: Research Challenges* (Clements 1999) and *An Analysis of Young Children’s Strategies and Use of Devices for Measurement* (Boulton-Lewis, Wilss, and Mutch 1996), the authors explain that their research found that children should be introduced to both standard and non-standard measuring implements beginning with their very first lesson in measurement. Both articles explain that this avoids errors associated with lack of exposure to standard measuring tools such as leaving a gap at the end of the ruler, leaving spaces between measures, and reading
the implement from the wrong starting point.\textsuperscript{34} Clements’ article suggests that using both standard and non-standard units from the beginning is “a more interesting and meaningful real-world activity for young children.”\textsuperscript{35} Though these articles do not directly apply to my students because of the age of the students studied, their findings are worth taking into account when planning my lessons. During my unit, I would like to have introduced rulers to my students, but at the time it did not seem developmentally appropriate. Looking back, I believe my students would have benefitted had rulers been put out on the shelf. We could have used them to practice measuring things as a group, and the students could have experimented with them in small groups and individually. Fortunately, I did make the procedural rules of measuring very clear (i.e. putting items back to back and measuring from one end point to the other).

Lastly, given that my study was observational in nature, I am relying on my experience as a teacher and the knowledge that I have gained through my research. Therefore, the study as a whole lacks a scientific nature. Also, the group that I was working with, my class of eight students, is incredibly homogenous and does not accurately reflect society as a whole. Therefore, this study cannot be defined as scientific because I did not analyze the data in a statistical way. Fortunately, my main goal was to find the activities that were most appropriate for teaching my eight students how to reason with measurement. I was not trying to apply these ideas or activities to society as a whole, nor would I suggest that these activities would be optimal for anyone else’s classroom. I was very pleased with the results that I saw in my classroom, because I was hearing great conversation, discussion, explanation, and reasoning going on in MY classroom. Therefore, I found that this unit was a success.

I learned quite a bit from the implementation of this unit. As a young teacher, I learned how much work it takes to ensure that the activities that I implement in my classroom are the most appropriate. It not only requires research, but it also requires interviews. I need to speak with teachers of older students to find out what they expect students to know when


\textsuperscript{35} Clements 7.
they get to their class. If I don’t ask, then my students might fall behind in the future. Also, other teachers have great information and experience about what worked for them and what failed. Research can take a teacher a long way, but the experiences of others can take a teacher the extra mile.

The greatest thing I discovered about each of our classroom investigations into measurement is how much prior knowledge the kids were using. Though I thought they didn’t know much about math concepts yet, they were able to call on their knowledge of numbers, number sense, patterns, size and comparison, and so much more. Plus, they were learning more about what they already knew. They also showed me how well-behaved and motivated they can be when they are truly interested in an activity. When we were doing experiments during circle time or cooking as a group, I did not have to correct any of my students’ behavior because they were so engaged. This was very refreshing for me because constant behavior correction can really disrupt a lesson and gets tiresome for a teacher. It turns out that my young students have a great deal of focus when they really enjoy the topic and the activity. This was very exciting for me to witness.

The hardest thing for me throughout this unit was trying to decide whether or not the students were learning how to reason. It is one thing for the students to learn how to use the language of measurement, but it is also important for them to learn how to apply their ideas and justify mathematical truths. Obviously my students are not proving theories and making sophisticated conjectures, but they are learning how to talk about measurement in a way that makes sense. I found that, by the end of the unit, very many of my students were engaged in a very developmentally appropriate version of mathematical reasoning.
Data and Findings

Appendix A - My Students (Names have been changed), Unit Progress, and their Daily News Responses:

Charting the Progress:

1 – Student recognizes the basic language of the concept but cannot apply the basic principles or reason with the concept
2 – Student has a basic knowledge of the language of the concept but cannot apply the basic principles or reason with the concept
3 – Student understands the basic language of the concept, applies the basic principles of the concept but cannot reason with the concept
4 – Student understands the basic language of the concept, applies the basic principles of the concept, and reasons with knowledge of concept

**Anna** – 4 years, 3 months
Beginning of Unit: 3
End of Unit: 4
Daily News - “On the scale I can see which goes higher and lower – it’s heavier and light.”

**Caroline** – 3 years, 11 months
Beginning of Unit: 3
End of Unit: 4
Daily News - “You can put different colors [of wooden cubes] on the lines when you play the measuring game.”

**Lanie** – 4 years, 2 months
Beginning of Unit: 2
End of Unit: 3
Daily News - “I know about measuring that I can measure with pencils.”

**Brady** – 3 years, 7 months
Beginning of Unit: 1
End of Unit: 2
Daily News - “I know how to measure with water!”

**William** – 4 years, 1 month
Beginning of Unit: 1
End of Unit: 3
Daily News - “This basket is five unit cubes long.”

**Graham** – 4 years, 3 months
Beginning of Unit: 2
End of Unit: 4
Daily News - “I was measuring my marker and then I colored with it.”

**Robert** – 4 years, 0 months
Beginning of Unit: 3
End of Unit: 4
Daily News - “Measuring is how big things are and how long they are.”

John – 4 years, 0 months
Beginning of Unit: 3
End of Unit: 4
Daily News - “When my mom tells me to do something, she measures. She measures me!”
## Appendix B - Lesson Plans:

### Week 1 – Fall Harvest and Farmer’s Market

<table>
<thead>
<tr>
<th></th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Circle Time/ Guiding Questions</strong></td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
</tr>
<tr>
<td></td>
<td>What Kinds of Vegetables Come From the Farm?</td>
<td>Why Do We Need Grains and Wheat?</td>
<td>Where Do Apples Come From?</td>
<td>How Do We Use Dairy and Eggs?</td>
<td>What is a Farmer’s Market?</td>
</tr>
<tr>
<td><strong>Measurement Skills</strong></td>
<td>Time Weather Intro to Measurement</td>
<td>Time Weather Length</td>
<td>Time Weather Length</td>
<td>Time Weather Height</td>
<td>Time Weather Length</td>
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<tr>
<td><strong>Circle Time Activities</strong></td>
<td>Introduce Measurement Game</td>
<td>Measure Masking Tape Lengths on the Floor with Shoes – Why is the number of shoes different?</td>
<td>Measure our Magic Wand? How many unit cubes/Legos/paper clips long is our wand?</td>
<td>Talk about cooking volumes – what would happen if we changed the recipe?</td>
<td>Introduce Inch by Inch story basket, talk about measuring with gummy worms</td>
</tr>
<tr>
<td><strong>Language Introduced</strong></td>
<td>Opposite Words in Measurement</td>
<td>Long, Short Sentences about length, Proper measuring techniques</td>
<td>Long, Short Sentences about length, Proper measuring techniques</td>
<td>Short, Tall Different Cooking Measurements</td>
<td>Sentences about length, Proper measuring techniques</td>
</tr>
<tr>
<td><strong>Art Project</strong></td>
<td>Paint with Ears of Corn</td>
<td>Thumbprint Ears of Corn</td>
<td>Paint and Lace apples for our apple tree</td>
<td>Watercolor – squeeze paint from a milking glove</td>
<td>None</td>
</tr>
<tr>
<td><strong>Literacy</strong></td>
<td>Many Ways to Measure by Michele Koomen</td>
<td>Super Sand Castle Saturday by Stuart J. Murphy</td>
<td>Apple Farmer Annie by Monica Wellington</td>
<td>Pancakes, Pancakes by Eric Carle</td>
<td>Inch by Inch by Leo Lionni</td>
</tr>
<tr>
<td><strong>Science</strong></td>
<td>None</td>
<td>Cooking – Popcorn</td>
<td>Cooking – Fruit Salad</td>
<td>Cooking - Pancakes</td>
<td>Cooking – Dirt Dessert</td>
</tr>
<tr>
<td><strong>Math</strong></td>
<td>Playing the Measurement Game</td>
<td>Measuring with shoes – Why are the results different?</td>
<td>“How many apples tall am I?”</td>
<td>“How Tall” game, Videos: “Measuring” and “Body Measuring” on SMART Board</td>
<td>Measure different items with gummy worms</td>
</tr>
<tr>
<td><strong>Specials</strong></td>
<td>Music</td>
<td>Chapel Motor Skills</td>
<td>Music</td>
<td>Motor Skills</td>
<td>Library Motor Skills</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>Observe if students participate in discussion about opposite words</td>
<td>Listen as kids discuss why the number of shoes it takes to measure is</td>
<td>Observe their understanding of “how many apples tall am I?”</td>
<td>Listen to answers about what happens when we change recipes</td>
<td>Observe for proper technique as students measure with</td>
</tr>
</tbody>
</table>
Week 2 – Learning about Thanksgiving

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle Time/Subject</td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
<td>Calendar Weather</td>
</tr>
<tr>
<td>What does it mean to give?</td>
<td>How can we learn from others?</td>
<td>What do we do when we are lost or need help?</td>
<td>What happened at the first Thanksgiving?</td>
<td>What do we have that’s special? What are we thankful for?</td>
</tr>
<tr>
<td>Measurement Skills</td>
<td>Length</td>
<td>Weight</td>
<td>Volume</td>
<td>Overview</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Overview</td>
</tr>
<tr>
<td>Circle Time Activities</td>
<td>“Can you find an item in our classroom that is 6 unit cubes long?”</td>
<td>Compare weight of different objects – introduce scale</td>
<td>Measuring with water and several different sized vessels</td>
<td>Tell the story of the real Thanksgiving</td>
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<td></td>
<td></td>
<td></td>
<td>Acting out the real story of Thanksgiving</td>
</tr>
<tr>
<td>Language Introduced</td>
<td>Long, Short</td>
<td>Heavy, Light, Weight, Scale</td>
<td>Empty, Full, Volume, Vessel, Scale</td>
<td>Review all opposite words and measuring words</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Review all opposite words and measuring words</td>
</tr>
<tr>
<td>Art Project</td>
<td>Color</td>
<td>Handprint wreath and handprint turkeys</td>
<td>“What I’m Thankful For” Cross</td>
<td>Arrowhead Necklaces</td>
</tr>
<tr>
<td></td>
<td>Thanksgiving placemats</td>
<td></td>
<td></td>
<td>“My Favorite Thing About Thanksgiving is…” page, Pilgrim Hats</td>
</tr>
<tr>
<td>Literacy</td>
<td>Letter of the Week - J</td>
<td>Mighty Maddie by Stuart J. Murphy</td>
<td>Just Enough Carrots by Stuart J. Murphy</td>
<td>Daily News about Measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Acting out the real story of Thanksgiving</td>
</tr>
<tr>
<td>Science</td>
<td>Cooking – Cheerio Snack Mix</td>
<td>Cooking – Macaroni and Cheese</td>
<td>Cooking – Rice Krispie Treats</td>
<td>Cooking – Banana Crepes</td>
</tr>
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</tr>
<tr>
<td>Math</td>
<td>Kids measure their own snack mix</td>
<td>Comparing weight – “Which Weighs More?” chart</td>
<td>Learning about volume</td>
<td>Measurement activities at sign-in</td>
</tr>
<tr>
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<td></td>
<td>Measuring our heads for pilgrim hats</td>
</tr>
<tr>
<td>Specials</td>
<td>Music</td>
<td>Chapel Motor Skills</td>
<td>Music</td>
<td>Motor Skills</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Library Motor Skills</td>
</tr>
<tr>
<td>Assessment</td>
<td>Listen and Observe - what do they find that is 6 unit cubes long?</td>
<td>Observe as the students compare weights.</td>
<td>Listen and Observe as we discuss different volumes</td>
<td>Observe as students complete measurement activities</td>
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<td></td>
<td>Observe as students act out the real story of Thanksgiving</td>
</tr>
</tbody>
</table>
Appendix C – Transcript of Assessment with Graham

Assessment of Skills and Understanding in Length Measurement:

Me – “First you’re going to use gummy worms to measure the line, and then you’re going to use unit cubes and then you’re going to try using doggie bones. So can you show me how to measure this line with gummy worms?”
Graham – “Uh-huh”

Graham measures.

Graham – “They’re the same size!”
Me – “They’re the same size! How many gummy worms did it take to measure that line? How many gummy worms are you holding?”
Graham – “One!”
Me – “Just one. So let’s talk about that line. This line is one gummy worm long. So try this one – let’s see what happens with this one.”

Graham measures.

Me – “One, two, three.”
Graham – “I did it!”
Me – “How many did it take?”
Graham – “Three!”
Me – “Three gummy worms. Three gummy worms long! Will you measure this one?”
Graham – “Yup!”
Me – “Now tell me about where you started on the line. Did you start here in the middle?”
Graham – “No.”
Me – “No.”
Graham – “I need a lot.”
Me – “You need a lot? Okay. Why do you need a lot?”
Graham – “Because it’s so long.”
Me – “It is? Okay, show me.”

Graham measures.

Graham – “Two?”
Me – “Two!”
Graham – “Awesome!”
Me – “Awesome.”
Another student – “What are you making?”
Me – “We’re measuring.”
Me – “So tell me about this one.”
Graham – “It’s two long.”
Me – “Two. Two what?”
Graham – “Two gummy worms!”
Me – “Yeah! Two gummy worms! Why did you start here on the line?”
Graham – “Because that’s where you start.”
Me – “That’s where you start? Where did you finish?”
Graham – “Right here.”
Me – “What’s that?”
Graham – “The end!”
Me – “So you started here at the beginning of the line and you finished here at the end?”
Graham – “Uh huh”
Me – “How come you don’t stop in the middle?”
Graham – “Because you can’t.”
Me – “Will you measure this line for me with unit cubes?”
Graham – “I’m going to use all the black ones.”
Me – “All the black ones?”
Graham – “Uh huh.”
Me – “Why do you want to use all the black ones?”
Graham – “Because it’s my favorite color.”
Me – “I knew that – I thought you might say that. Do you think that’s going to be enough?”
Graham – “Yes.”

Graham measures.

Me – “Okay. What are you doing?”
Graham – “I’m putting them on the line.”
Me – “That’s a good idea. Why did you do that?”
Graham – “Because you have to put them on the line so that you can measure!”
Me – “Wow! Cool!”
Graham – “Awesome – it’s the perfect size.”
Me – “Will you count how many you have?”
Graham – “1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.”
Me – “Will you count them for me again?”
Graham – “1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.”
Me – “Let’s count them together.”
Together – “1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11.”
Me – “So tell me about this line.”
Graham – “So it’s all together.”
Me – “Tell me about this line. What would my sentence be?”
Graham – “Because the…”
Me – “How many unit cubes was it?”
Graham – “Eleven.”
Me – “This line is…”
Graham – “This line is 11…”
Me – “Eleven whats?”
Graham – “Eleven unit cubes!”
Me – “Let’s try measuring this line with dog bones.”
Graham – “Dog bones?”
Me – “Yeah!”

Graham measures.

Me – “Why did you start there?”
Graham – “Because that’s where you start.”
Me – “You start where? At the beginning?”
Graham – “Yeah.”
Me – “What happened?”
Graham – “I got one, two, three, four.”
Me – “Four what?”
Graham – “Four doggie bones!”
Me – “Yes – I wrote the number four there – this line is four dog bones long. When we get back from motor will you help me measure the rest of these lines?”
Graham – “Yup.”
Me – “Okay friends get in line please!”

Kids go to motor…

Me – “Now, will you measure this line and use dog bones for me?”
Graham – (Inaudible) “…I’m going to dump them all out.”
Me – “Will you use these dog bones to measure this line?”

Graham measures.

Graham – “1, 2, 3, 4, 5.”
Me – “Let’s think about this. What about that space in there? Is that space going to get measured if you have the dog bones so far apart?”
Graham – “I like them like this so I can see the line.”
Me – “But will the whole line get measured if you leave that much space in between the bones?”
Graham – “No.”
Me – “Let’s try it like this and see what happens.”
Me – “Let’s count the way you had it. Let’s count the way you had it. You had them like that – now count how many bones it takes to get from the beginning to the end.”
Graham – “1, 2, 3, 4, 5!”
Me – “Now let’s see what happens when I put them right next to each other. Let’s see if we can fit another one. Can another bone fit?”

We put the bones one next to the other.

Graham – “Yes.”
Me – “Now count how many.”
Graham – “1, 2, 3, 4, 5, 6!”
Me – “Good. Let’s count together.”
Together – “1, 2, 3, 4, 5, 6!”
Me – “This line is 6 dog bones long. It made a big difference didn’t it? When you had only five – look at all that space you had left. A whole ‘nother bone fit in there. Will you measure this line with dog bones?”
Graham – “Uh huh.”
Me – “Can you measure this line with dog bones? Will you measure this one for me?”

Begins to measure
Me – “That’s a lot! Do you think you need that many?”
Graham – “Uh huh.”
Me – “Tell me what you’re doing when you do it. How many did it take?”
Graham – “Two.”
Me – “Two what?”
Graham – “Two doggie bones.”
Me – “Now will you measure this?”
Graham – “Let’s make a pattern – black, orange. Black, orange.”
Me – “Okay!”
Graham – “Black, orange.”
Me – “What comes next?” (A crowd has joined to see what Graham is so excited about.)
Many students in unison – “Black!”
Me – “Good! And then what?”
Many students in unison – “Orange!”
Me – “Good job. Now let’s count them together.”
Many students and me – “1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16!”
Me – “16! That’s a lot!”
Me – “Okay – will you measure this one for me?”

Graham measures.

Me – “Now how many do you have?”
Graham – “1, 2, 3, 4, 5.”
Me – “5! Wow! So this line is 5 unit cubes long, 1 gummy worm long, and 2 dog bones long. Cool! Now this line is 2 gummy worms long, 11 unit cubes long, and 4 dog bones long. Hm. This line is 3 gummy worms long, 16 unit cubes long, and 6 dog bones long. Which one is the longest line?”

Points to longest line.

Me – “And which one is the shortest line?”

Points to shortest line.

Me – “Yeah! So cool! How do you know it’s the shortest?”
Graham – “Because it’s so small.”
Me – “It is so small. What is this one? What would you say about this one? If this one is the longest and this one is the shortest – then what’s this one?”
Graham – “Medium!”
Me – “Oh okay. The medium one!”

Points to medium. Graham - “Medium.”
Points to shortest. Graham – “Small.”
Points to longest. Graham – “Big.”
Me – “Good job, Graham! You did a really good job measuring – thanks for helping me. Now go help your friends clean up.”
Works Consulted

Beta Exit/Pre-K Entrance Expectations – Presbyterian School Houston, Texas.


Cesarone, Bernard, “Storytelling Sagas: An Effective Medium for Teaching Early Childhood Mathematics,” *Childhood Education*, Olney, Vol. 84, Iss. 3 (Spring, 2008), p. 188.


Lampert, Magdalene. Teaching Problems and the Problems of Teaching


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