Presidential Award Winners

Nurturing the Numeracy That Is Present In All Children

By Kathryn D. Chandler

Abstract. In this paper, the author elaborates on constructivist teaching methods that she has successfully employed during the past eleven years as a kindergarten teacher in a full-day program. Numerous model exercises are discussed and accompanied by anecdotal assessments of their effectiveness.

Evidence of Talent in Teaching

I am a facilitator and guide on my students' journeys in the learning process. My endeavors have led me to design problem-solving books, math games, and daily living activities that allow children to construct sound and significant mathematical concepts. These tasks are meaningful to children and allow them to learn in an authentic context. For each unit that I teach, I have written personalized problem-solving books which typically contain students' names, favorite toys, and interests. In addition, I have created games for each objective in the mathematics curriculum and encourage students to create their own games. Students in my classroom participate in daily routines in which they apply mathematical concepts and reasoning skills. This innovative approach allows children to have a larger stake in their own education and learn at a level that is developmentally appropriate for them.

The following are goals stated in the *Alabama State Course of Study* (1997, pp.13-15) for kindergarten mathematics programs:

(a) Compare numbers and sets of objects up to 10
(b) Demonstrate one-to-one correspondence using a variety of objects that relate to real-life situations
(c) Develop an awareness of addition.

The National Council of the Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards (1995) and *The National Board for Professional Teaching Standards for Early Childhood Generalists* (1998) advocate the use of problem solving, games, and everyday situations to meet these goals.

My overall goal during the math unit has been for students to construct an understanding of the concept of number. One specific objective is comparing and adding numbers and sets of objects with sums as large as 12. There have been several students for whom I have modified this objective. Students with only beginning mathematical concepts (BMC) count and compare sets of objects as large as six. Several students with strong mathematical concepts (SMC) count, add, and compare sets of objects with sums as large as 20. Another objective is for students to demonstrate one-to-one correspondence in solving problems and in math games. The third objective is for students to develop addition skills.

Kindergarten children naturally think about numbers in their everyday lives. They know that it is not fair when a friend has more pieces of candy than they do. They are excited when they are able to ride a bike with two wheels. Children learn best when they can use their prior knowledge of numbers in order to construct more difficult numerical concepts. Problem solving is an effective way to accomplish this end.

For this unit, I have created problem-solving books based on content about the farm. Students have practice solving questions using a variety of methods. The following are examples of questions that I have developed, in which students are expected to solve problems with addends as large as 6 and sums as large as 12. For example:

(a) The farmer planted 4 rows of carrots with 3 carrots in each row. How many carrots did he plant altogether?
(b) Inside a barn in the country, a mouse woke up 2 horses, 4 cows, and 5 sheep. How many animals did the mouse wake up in all?
(c) In the garden, there are 3 stalks of corn with 3 ears on each stalk. How many ears of corn are there altogether?

We begin our math time with a class discussion in order for students to share unique ways of solving a problem. The following

is a question that we solved as a class: "Old McDonald had 5 goats, 5 pigs, and 2 sheep. How many farm animals did he have in all?"

Heather said: "I think that it is 12 because 5 and 5 make 10. Then you go 11, 12."

Chris said: "My answer is 12 because 2 and 5 make 7. Then you count, 8, 9, 10, 11, 12."

These students found sums that they knew, and then they "counted on" to complete their answer. Other children counted on their fingers and drew imaginary lines in the air to get their answers. This type of communication between students allows them to consider new ways of solving problems. Chase created another problem for us during this discussion. He said: "Hey, what if Old McDonald got some chickens?" I followed his lead and asked him how many chickens he thought that Old McDonald might get. Chase said: "I think 3." We added three chickens to our problem and again discussed our answers. The students worked independently to solve a similar problem. Next, they shared their work with a peer to see if they both agreed on the answer.

I meet the individual needs of the children during problem solving time through several strategies, including working one-on-one or working with a small group of students who require additional attention. I also pair students with strong mathematical concepts with students with developing mathematical concepts to share answers. Students play math games when they complete the problem for the day.

I have selected the following math games to help students meet the goals of the unit: Card War, Double Card war, Double Dice War, Golf, and Basketball. Students learn skills such as counting, more/less, one-to-one correspondence, sequencing, sorting, addition, and logical reasoning by playing math games. They are effective tools for the following reasons (Kamii, 1985):

(a) Students have a personal stake in the content
(b) Feedback is immediate
(c) Feedback comes from their peers
(d) Students are mentally active each moment because they are supervising their peers, and
(e) Students are motivated to learn.

Card War requires two players and a deck of cards with the face cards removed. The cards are divided equally between the players. Each player places his top card face up on the table. The student must count or recognize the number on his card and his partner's card. The student with the highest number wins both cards. The player with the most cards at the end of the game is the winner. *Dice War* is a similar game. This game requires two

players, two dice and a way to keep score. Each player rolls two dice and adds the numbers together. The player with the highest total wins one point for the round. The first player to win 10 rounds wins the game.

I modify Card War and Dice War to meet the needs of individual children. In Card War, I select numbers 1 - 6 from the deck for students with beginning mathematical concepts (BMC). Students with developing mathematical concepts (DMC) play *Double Card War* with numbers 1 - 6. In this game, the players select two cards from the top of their deck and place them face up on the table. The students must add their two cards and compare their score with their opponents' score to determine who will win the cards. Students with strong mathematical concepts (SMC) may use numbers 1 - 10 when playing Double Card War. I modify Dice War as well. One die may be used in the game for BMC students. Two dice may be used for DMC students. SMC students may use two dice with faces numbered from 5 - 10. Children create their own modifications. Kasey asked if she could play Double Card War with the face cards in the deck. I asked her how she could use them in the game. She said that the face cards could count ten points each. Kasey taught this version of the game to several other SMC students.

Many of my students have older siblings or parents who enjoy playing golf and basketball. Since I know that students have this prior knowledge, I have created math games based on their interests. In the *golf game,* there are six holes numbered with point values ranging from 1 - 6. Students putt as many times as necessary to sink two golf balls. After each round, the players add their point values and compare. The player with the highest score wins one point for the round. The points are added at the end of math time to determine the winner of the game. In the *basketball game,* students throw four balls at the goal. Three points are scored for each basket. At the end of the round, the player with the highest score wins. The player that wins the most rounds wins the game. I modify the point value in the basketball and golf games to meet individual needs. Students modify the basketball game by allowing players to shoot as many baskets as possible within a time limit.

Barnyard Toss is another game that I have created for the math unit. In this game, students throw 2 bean bags on a barnyard poster. Each animal on the poster has a different point value ranging from 1 - 6. Students with developing mathematical concepts add the points together and compare their sum with their partner's sum. The player with the highest score wins the round. The first player to win 10 rounds wins the game. I modify the game for students with beginning mathematical concepts. These

students throw one bean bag each on the board. The player with the highest number wins the round. Students with strong mathematical concepts throw 3 bean bags on the board then add and compare their sums to determine the winner.

One of our daily routines is center time. An activity that I have formulated for center time is that of modeling graphs, after which I have students create their own graphs. Examples of my graphs include:

(a) Do you like your eggs scrambled, fried, or boiled?
(b) Which do you like best: chocolate milk, strawberry milk, or whole milk?
(c) Which farm animal do you like best: cows, chickens, or pigs?

Examples of graphs that my children have created include the following:

(a) What is your favorite baby animal: piglets, calves, or chicks?
(b) What is your favorite vegetable: carrots, potatoes, or broccoli?
(c) If you were a farmer, what animal would you like to feed: a sheep, a goat, or a cow?

When students use these graphs, they count and compare sets.

Other centers also allow children to think about numerical concepts. For example, two students built a fence for the farm animals in the blocks center. They divided the farm animals between the two of them and began to play. Another child entered the center and told them that it wasn't fair that they had all of the animals. The students decided to divide the animals among the three of them. These students counted the set of animals, divided them into three piles, then compared each pile to make sure that it was fair.

I use routine tasks such as taking attendance, lunch count, or cleaning the room to facilitate the development of mathematical reasoning. Discussion about "more and less" naturally occurs as a child takes the lunch count. I give students the responsibility of counting the number of students present and absent. I ask students to pick up 7 items from the floor and to sort objects during clean up time.

Voting on important classroom issues is a meaningful task in which students compare sets of numbers. On sunny days, we vote whether to eat our lunch in the cafeteria or at the tables in the courtyard. When it is raining during recess, we vote on whether to play centers, puzzles, or math games. Students also initiate votes. To cite an example, when a student moved into our class in March,

several students asked me if we could vote on a new job for the job chart. I held a class meeting in which students discussed several options and took a vote. Students looked around the group and counted, for themselves, the result of each vote. After they had a chance to do so, I let them tell me the numbers. Cleaning the tables received 6 votes; cleaning the easel received 10 votes; and sweeping the floor received one vote. We discussed which jobs had the most and least votes. I use meaningful activities such as these to encourage students to gain an understanding of how numbers affect their everyday lives.

Assessment of Student Learning

Authentic learning demands authentic assessment. I keep anecdotal records based on observations and student portfolios to demonstrate student growth. Portfolios are particularly helpful in parent and student conferences. I use dated work samples and pictures or videos of student work in the portfolios. The purpose of authentic assessment is to recognize student growth and plan further instruction.

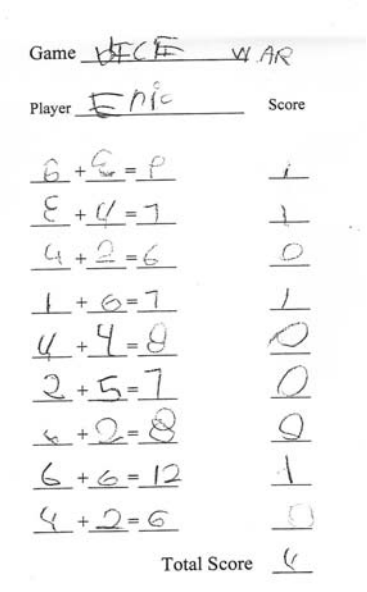
As students are working in their problem-solving books, I observe and listen to their conversations. I record students' remarks that show their thinking process and note ways students solve their problems. Examples of notes taken include: "Justice struggled with one-to-one correspondence"; "Brooks counted on his fingers in the addition task"; "Kailey asked a friend for help"; "Sydney had difficulty structuring a method to determine her answer"; "Eric used plus, minus, and equal signs correctly"; or "Taylor used a more efficient method of determining his answer than he had previously used." I review these comments during my planning period to think about new ways to challenge individual students.

A review of the problem-solving books are revealing as well. Some students may draw the objects and then count them. Others may use lines, stars, or other representational symbols when finding their answers. All of these methods reveal a child's thinking. In assessing these activities, I consider not only the child's answer but also the thinking that led to the answer.

I also make anecdotal records during observations of math games. Examples of anecdotal notes include: "Amelia mentally added numbers without using paper and pencil"; "Kayla counted on her fingers to determine the correct answer (photograph 12)"; "Chris corrected his answer when Chase questioned it"; "Kayce defended her answer when questioned by Ussama"; "Anam used paper and pencil to determine her answer"; "Breanna accurately kept score on her paper"; or "Sidney used manipulatives to determine her answer."

The score sheet from a math game is an authentic assessment. I use these sheets to determine how well a student is able to compare sets and solve simple addition problems. In the fall semester, students kept score on blank paper. I observed how students aligned the numbers and the methods they used in determining their answers. I introduced some of the special knowledge that students would need to use when writing addition equations with the current score sheet. We discussed the plus and equal signs and how to use them appropriately. The students then applied this knowledge in recording their scores.

The work sample below is a score sheet that my student Eric used to play Double Dice War, using dice with faces numbered from 1 - 6. He placed the addends and the sums in the correct blanks. He also accurately compared sets of objects by keeping the correct score for each round of play. While Eric played this game, I noticed that he automatically recalled the correct answers for doubles. In this game, he rolled the doubles $4+4$ and $6+6$. He also "counted on" instead of counting each dot on the dice. For example, in the equation $2+5=7$, Eric looked at one of the dice and said: "5." He then proceeded to count on the next dice: "6, 7." Eric's classmate Taylor monitored and discussed Eric's answer. I have determined from his recent work, including this assessment, that Eric is ready to play games with addends as large as 10 and sums as large as 20.



Game DECE WAR

Player Eric Score

6 + 6 = 12	1
5 + 4 = 9	1
4 + 2 = 6	0
1 + 6 = 7	1
4 + 4 = 8	0
2 + 5 = 7	0
6 + 2 = 8	0
6 + 6 = 12	1
4 + 2 = 6	0
Total Score	4

Recall that, in the *golf game,* there are six holes numbered with point values ranging from 1 - 6 and that students putt as many times as necessary to sink two golf balls. It is interesting to see which students aim for the holes with higher point values, even though they are more difficult to reach. The students use the same scoring sheet in this game that they use in Dice War. Students remain engaged because of their high interest in the game. During one game, Chris and Kayce were partners. After several shots, Chris reached hole number 6. His next score was a 1. Kayce made 5 points on her first ball. She then said to Chris: "If I make two points, we can tie!" Kayce then aimed for the 2-point hole. Kayce not only computed Chris' score, but also determined what she would need to make on her second hole so that her score and Chris' score would be equal. Because of these strong mathematical concepts, I changed the game for Kayce. Kayce and her math partner drew a number at the beginning of each round and tried to make that exact score. Each time they made that score a different way, they made a point.

Recall that, in the *basketball game,* students throw four balls at the goal, and that three points are scored for each basket. At the end of the round, the player with the highest score wins. In one such game, Jordan scored 9 points and Breanna scored 6 points. These students then decided to change the rules of the game. Jordan said: "Hey, why don't we see how many points we can score in one minute?" Breanna agreed that she would like to try this variation of the game. I asked the students how they would know that one minute had passed. Jordan decided to use the timer that we usually set for the library. Both students had a great time shooting the baskets but didn't remember to keep their own score. I asked them what they thought a good solution would be for keeping score when they had only a small amount of time to shoot the baskets. Breanna suggested that the player who was not shooting baskets could record the score for their partner. These students took responsibility for their own learning. They took on a much more complex task than I would have given them. My instructional decisions were based on the lead of the child.

Amelia has stronger mathematical concepts than Sidney, so I paired them together for a game of Double Card War with addends as large as 6 and sums as large as 12. Sidney watched Amelia carefully during the game to determine a good way to compute her answers (sums). Sidney had been playing Card War in which she had to count numbers as large as 6 and then compare her card to her partner's card. I moved Sidney to Double Card War because of her recent progress with one-to-one correspondence and comparing sets of objects. This information about Sidney came

from my observations and her score sheets. Sidney counted each set of objects on her cards several times before deciding on her answer. Amelia showed Sidney how to record her score on the new sheet. I reviewed Sidney's score sheet after the game. Although Sidney did not have correct answers for each of her scores, she did show significant progress. I decided to continue to allow her to play Double Card War when I placed her with a SMC student or played with her myself.

Sidney and Kayla compared their scores for double dice war. Sidney noticed that Kayla counted on her fingers to get her answer. Kayla automatically recognizes the numbers on the dice, yet still preferred to count on her fingers rather than counting the dots on the dice. Sidney began to use this strategy herself. Fingers are portable manipulatives, so counting on them is a good strategy to use until a child develops stronger mathematical concepts and no longer needs manipulatives.

Daily routines are a part of mathematics assessment as well. Each child has a job in my classroom. They perform their job for one week at a time. The second week in April was Anam's turn to take attendance. When Anam had this job in January, she counted only children sitting at their tables doing their work. She did not count the students who were still unpacking or sharpening pencils. Anam also forgot to count herself. Last week, however, Anam asked how many students were in our class. I told her that we had seventeen students. Anam asked students at each table if there were any students missing. She recorded only the names of the students who were missing. When she handed the attendance to me, she said: "Justice and Sydney are out today. That makes 15." Although I would not have given a kindergarten student the problem $17 - 2$, Anam created this problem and answer for herself. This afforded me another opportunity to follow the lead of the child in making instructional decisions.

Students think about the concept of number when they take the lunch count. One student has this job each week also. Last week was Heather's turn. Heather walked around the room and asked students if they would like Hamburgers or Crispitos (I don't know what it is either) for lunch. When she returned, she said: "10 for hamburgers and 4 for Crispitos, please. That means hamburgers won!" (The other students had brought their lunches from home.) In this task, Heather accurately used one-to-one correspondence and compared sets of numbers. I asked Heather if she would like to make any other graphs. She thought of the following questions:

(a) What is your favorite toy?
(b) Do you like ice cream?
(c) What is your favorite color?

Heather asked her questions to the class and recorded them on graph paper. We then discussed the graphs with the class. The excitement spread and several students began their own graphs.

The strength in these assessments lies in their ability to be of service to the learner. The learner is invested in the process and will continue to progress by constructing new information about the world. In a classroom in which assessment and learning occur simultaneously, no additional instructional time is lost on contrived assessments. This authentic assessment enhances learning in a meaningful context.

References

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