THE EFFECTIVE USE OF MANIPULATIVES

(as seen in CORE PLUS)

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CURRICULUM PHILOSOPHIES

In the Fall of 1999, the high schools in the Bethlehem Area School District, Bethlehem, PA implemented a new mathematics curriculum. The Contemporary Mathematics in Context, developed by the Core-Plus Mathematics Project, is a four-year integrated mathematics program. It was designed to fulfill the purpose of high school mathematics as portrayed by the National Council of Teachers of Mathematics (NCTM).

This new curriculum follows the belief of mathematics as sense making. Through investigations of real-life contexts, students develop a rich understanding of important mathematics that makes sense to them and enables them to make sense out of new problems and situations. This new approach stresses multiple topics or strands of math, mathematical modeling, technology uses, and active learning. With different strands, a diverse population can be reached by nurturing the multiple strengths and talents of your students. The modeling perspective lets students experience mathematics as a means of making sense of problems. Technology allows students to deal with realistic situations in a more technical, rapid fashion along with visualizing math in a new way. And finally, students are active in their learning and find that math is not a spectator sport.

Core Plus follows a basic checklist for learning. In class, a topic is launched (introduced), explored (investigated with manipulatives and technology), summarized (conclusions), and applied (real-life situations internalized by the students). The majority of learning takes place with active learning and collaborative work. Cooperative learning is an effective way for engaging all students in the learning process. They practice for

real life and learn valuable social skills. While in these groups, students will investigate various problems and work together to solve them. How are they solving them? Well, that is where the manipulatives come in. Core Plus stresses learning by experiment and discovery, in other words, *effectively using manipulatives*.

EFFECTIVE USES OF MANIPULATIVES

Research in England, Japan, China, and the United States supports the idea that mathematics instruction and student mathematics understanding will be more effective if manipulative materials are used (*Improving Mathematics Teaching by Using Manipulatives;* James W. Heddens, Kent State University). A mathematical manipulative is defined as any material or object from the real world that children move around to show a mathematics concept. They are concrete, hands-on models that appeal to the senses and can be touched by students. These materials should relate to a student's real world. For example, an abacus isn't used in daily life, but items like stones, blocks, beans, marbles, rubber bands, and peanuts would be more appropriate. One of the best ways in which mathematical ideas may be developed or applied is through activities with physical materials or manipulatives.

To begin, students explore with these manipulatives. It's very important for them to become familiar with the items and make observations. The teacher can model their use, but it's preferred to allow a student to work a problem with a partner or a group and then share their results on how they used the materials. Students learn best when they are active participants in the learning process. They assimilate knowledge when given

the opportunity to explore, investigate, question, describe, record, share, and talk about their discoveries.

Some advantages of hands-on materials include suitability for all age and ability levels, student-centeredness, holistically taught skills, fostering of peer and tutor interactions, multi-level challenges, and insulting to no one. Using manipulatives in teaching mathematics will help students learn to relate real world situations to mathematics symbolism, work together cooperatively in solving problems, discuss mathematical ideas and concepts, verbalize their mathematics thinking, solve problems without teacher direction, and learn that there are many different ways to solve problems. Manipulative use is a fun, easy way to introduce and visualize a concept. Textbook problems are brought to life and students can build their confidence by giving them a way to assess and confirm their reasoning. In using manipulatives…"the results are a better understanding and retention of mathematics, a decrease in math anxiety, and a heightened confidence level among students who have really made a lesson their own" (*Pictorial Journal Writing in Mathematics;* Andi Stix, Ed. D., 1992).

In keeping with the real world theme, the uses of manipulatives apply to post high school careers. Adults frequently use models when solving problems in the workplace, both concrete and computer-generated. For example, architects construct models of bridges and buildings. And yes, computer-based materials are considered manipulatives because they can be moved, assembled, and disassembled. Students using manipulatives develop a firmer conceptual foundation in thinking and reasoning skills, as favored by future employers.

As we explore the effective use of manipulatives, let's not forget to mention Piaget. Research has found that children move through three developmental learning stages: the concrete or manipulative, the representational or transitional, and the abstract. At the start of kindergarten, children are in the concrete stage where they must touch things and move them around to develop basic math concepts. "Piaget has found that the majority of children do not become abstract until between the ages of twelve and fourteen. To assist the movement through the transitional stage to the abstract, students must be provided with developmentally appropriate materials and activities. Studies confirm that manipulatives are the missing link to help students move from the concrete to the abstract stage. These studies also find that students who learn math with these types of models understand math better, develop better problem-solving skills and do better on standardized achievement tests." (*The Three Stages of Learning;* www.movingwithmath.com).

In conclusion, mathematics teachers are learning to direct their attention toward facilitating students' understanding and conceptualization rather than drill and practice procedures. The effective use of manipulative materials in mathematics classrooms supports this attempt. Incorporating the use of manipulative materials with an emphasis upon the thought process of students provides an opportunity for the teacher to assess and meet the needs of students as they construct personal mathematical knowledge. Using manipulatives may make the instruction period longer initially, but students retain the knowledge better and will require less review time later.

EXAMPLES OF MANIPULATIVE USE IN THE CLASSROOM

At the time of this writing, I have completed Units 1, 2 and 3 of the Core Plus program in my classroom. I began teaching this in Spring 2000. Some of my colleagues had already completed the teaching of year one in the Fall 1999 semester, so I was able to bank on their past experience to make mine more effective. The remainder of this paper will explore *some* uses of manipulatives in my classroom thus far.

p. 3 Collecting and Analyzing Data

Each group used measuring tapes, meter sticks, and string to collect data. For one project, students had to measure their heights and arm spans; for the second project, students measured the circumferences of their thumbs and wrists. This data was physically collected and recorded in a data table. The students then had to analyze the figures and locate any strong relationships between the measurements. I feel this activity was successful because the students gathered their own data as opposed to having it given to them. Since this was the first activity in the book, the groups also used this activity to get to know each other.

p. 19 Producing Plots with Technology

This activity was the first to use the graphing calculator as the manipulative. Prior to this investigation, students were creating number line plots and histograms by hand. They were also trained to describe these distributions. Now, with this activity, students were able to produce plots with great speed and were now able to work with larger data. By saving time, students are drawn in to the benefits of using technology to learn. At

this stage of the game, half the class had prior experience with graphing calculators. So, I used this opportunity to pair up students and make them graphing calculator tutors. Not only did I build confidence in half my students, I created better learning environments for those who needed individual help. The experienced students learn by teaching, the inexperienced students are confident they can learn because their peers have done it already.

p. 34 Calculating Measures of Center

Prior to this activity, students were discovering ways to find certain statistics about given data. We discussed ways to find a middle number, an average, and a number that occurs the most. The objective was to find a number that's representative of the data. After much discussion, I led the class to the graphing calculator's ability to help us with these statistics. The students used the calculators to quickly analyze data and retrieve valuable information in a short amount of time. To illustrate the importance and real life application, I input the grades from the last assessment into a list, and displayed it on the overhead calculator. I asked for five volunteers to come up and display a certain statistic. One showed us how to do the mean, one showed us how to find the median, one found the min and max, one sorted the data so we could see the range, and one produced a histogram of the grades. I later did the same activity when quarter grades were due. This led to a good discussion about how the class was doing as a whole and made students realize that teachers learn a lot from analyzing data.

p. 99 Modeling a Bungee Apparatus

The manipulatives used in this activity included baggies, rubber bands, paper clips, marbles, pennies, golf balls and rulers. Each group had to model a bungee apparatus. They attached rubber bands to baggies using the paper clips. Then, each group had a different material to model “weights” being added to a bungee jump. As each weight was added, students had to record the weight used and the length of the rubber band (cord) during the initial drop. Five trials were performed, each with more weight added on. Then, students made a scatter plot with the data to see if a pattern occurred. The groups had to predict what would happen, and this activity confirmed that the distance a bungee jumper falls before bouncing back upward depended on the jumper’s weight. By performing the experiment and graphing the results students were successfully able to prove their reasoning of a linear pattern. And, as I overheard one student say, “seeing is believing”.

p. 122 Money Matters

The graphing calculator was used here to help students better understand money matters. One topic of discussion was installment buying. The students were able to use the table function of the graphing calculator to understand how long it would take to pay off an item when using installment buying. We were able to change monthly charges in an instant to see the effects a few more dollars a month would make on long-term loans. This lesson is extremely important now that most of my students are working part-time jobs and are making their first large purchases…stereos and cars. Another topic discussed was interest, savings, and loans. The calculator allowed us to effectively

make predictions and see how quickly interest adds up and how long it would take to save certain amounts of money. This has real life application for students saving for cars or college.

p. 142 What Goes Up…Must Come Down

A tennis ball was used to make my point in this investigation. I threw a tennis ball to a student and asked the class to predict what a graph of its velocity would be. Originally, students predicted an arch shape, due to the path of the ball. However, after we defined velocity correctly, I threw the ball again and the students noticed that the ball travels fastest upon release from my hand and slowest when caught across the room. By using the graphing calculator, we confirmed the descending line. I proceed with a discussion about the graph of the ball's height. And, with the aid of a visual demonstration, my students were able to predict (by sight) and confirm (by graphing calculator) the shape of the graph of a ball's height when thrown in the air.

p. 159 Predicting Data (Rolling Stock)

This activity is not in the Core Plus text. During training, we received an activity, which uses textbooks, ramps, cars, and measuring sticks as manipulatives. Students started with 3 of the same textbooks and laid a ramp from the top to the ground. A car was rolled down the ramp and its distance was recorded. This process was repeated five times, each with a different starting height (a textbook was added for each trial). The groups made a table of height verses car distance, and graphed the ordered pairs. Analysis of this data produced a linear pattern. We discussed that a linear pattern

illustrates a continuous, constant change. As a result, we were able to predict a car's distance for ANY initial height.

With Unit 3 Lesson 2 – "Green Globs" computer software

At Freedom High School, we have software installed in our computer lab entitled Green Globs. As we begin our discussion of equations of lines, some students have trouble seeing the y-intercepts, slopes, and their purpose to these equations. This computer program displays an x and y axis along with green globs or spots all over the screen. The object of the game is to write an equation of a line that, when drawn, will connect as many green globs as it can. The more green globs hit, the more points a student receives on the scoreboard. This activity helps students find the slope and y intercept of a line, when given 2 or more points on it. I post the "scores to beat" and the students are allowed to get on the computer when all their work for the day is complete. We have two levels posted at this time, "novice" and "expert". After using this activity, I found students were better able to write equations of lines from a given graph. This conclusion was confirmed on the subsequent quiz. Some of my students do not have the mandatory computer contracts signed, therefore they are denied access to any computer use in any class. These students did not perform as well as the others.

This concludes my report on the effective use of manipulatives in the classroom. I must admit that I was a skeptic during summer training. I am a traditionalist at heart and as a new teacher I wanted to perfect my traditional style before trying a new one. I must say that my mind has been changed. I feel extremely confident in my effectiveness as a teacher and am pleased with the results from my students. I do get positive

feedback from my Core Plus mentor, Nancy Eckert, and I do see great improvements in students who haven't performed well in math in the past. What a great feeling to hear a student say "Wow, this is the first year I got a B in math". And, although I haven't cured all problems like 100% homework completion and 100% participation, I do know that every student leaves my class having learned something that day. **And that, my friend, is a FACT that requires no research.**

MANIPULATIVES USED

The following is a list of manipulatives used during the research of this article…

- Measuring tape
- Meter sticks
- String
- Rulers
- Graphing calculators
- Graph paper
- Sandwich baggies
- Rubber bands
- Paper clips
- Marbles
- Pennies
- Golf balls
- Tennis balls
- Ramps
- Toy cars
- Green Globs software

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