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Building Benches and Learning Math Standards on Zia Pueblo

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Introduction

"I LIKE BUILDING THINGS because I like to work with my hands," said David Pino Jr., a seventh-grade student in our math class. "I don't like to sit in my chair all period long; if I sit too long I will get bored and start to mess around." Many of the students in my math class come into the program with strong aversions to math. I believe my job as teacher is to motivate them with engaging, rich math problems they can use in the community or at a future job. Working out math problems while using their hands enriches the core math standards I teach and gets the kids to want to come to math class. For example, building benches using our measurement and numeracy skills helps my students learn. This idea was borne out in a hands-on, community supported project I initiated with a group of middle school students on Zia Pueblo, in which students used measurement and numeracy skills to build benches for the school grounds.

Many of my students arrive at class in the beginning of the year with a strong fear of math. All of the students in my class are very smart, yet are overwhelmed when they see a problem they have not worked out before. Though struggling, they realize that learning math is a process of trial and error in the classroom. I am so proud of the students' ability to work through times of frustration and master math skills and concepts given to them. Alonzo Peralta, seventh grader, states the process of mastering math skills and concepts best when he says, "When I first came [into] math class the teacher put some problems on the board and it was hard and when two weeks came and he put the same problems on the board it was easy." I am constantly amazed at what my students can do.

As teachers, we sometimes see students struggling and worry if they are going to get the ideas and concepts we are teaching them. We wonder: Is what I am teaching them too hard? Every time I have taken a risk and pushed limits with the kids at T'siya Elementary and Middle School (TEMS), they have responded with the hard work and respect that they have learned from their parents, their culture, and their community. Every time I have seen tough times hit this community I have also seen a great togetherness, where neighbors stick by each other and do whatever is necessary to get the job done. When I planned the project with the kids and worked out the red tape, I began to believe that if the community was behind it, we would get these benches done and done well.

At the time this project was undertaken, I was a math teacher and Special Education Coordinator at TEMS. The school is located 40

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miles northwest of Albuquerque, New Mexico, on the Zia Pueblo. (In New Mexico there are 19 pueblos, all of which are sovereign nations.) The people of Zia speak their native language of Keres as well as English. The school has grades K–8 and is open to any child who is Native American. However, it is mainly made up of people who live on Zia Pueblo. The community is very proud of having a local school that embraces the culture of the people.

Zia Pueblo is a special place with stunning views of the reddish Sandia Mountains to the east and similarly colored Jemez Mountains to the northwest. Far off to the south you can see a bright white mesa, which is a tribally owned gypsum mine used to make the sheetrock like the kind that covers the interior walls of most houses. The main pueblo is high upon a hill with a church. The school is due east a half mile on another mesa. The Big Chief gas station resides on the reservation and many of the kids run under the highway through the tunnel to get snacks there.

This school made Adequate Yearly Progress (AYP) for three out of the past four years. We have a very devoted, mixed staff of community members as well as others, who drive up to an hour each way to work with the students. Our student-teacher ratios are low; we have extended tutoring after school, and have competitive cross-country and basketball teams. Many students on the cross-country team, after graduating from middle school, are heavily recruited by local high schools.

We are also an inclusive school. We value all students and want our students with disabilities and those without to actively work together. We look at what our students can do and build programs based on their strengths. Everyone is included in all our classes. This practice comes from a belief in total community involvement in religious, ceremonial, and civic activities. This community believes students all have something to offer and should be encouraged to participate in anything they want to.

Our Framework for Learning

The theoretical framework of this project and my teaching philosophy come from the work of Csikszentmihalyi (1990), Dewey (1956), and Vygotsky (1934/1986). Csikszentmihalyi's work on "flow" inspired me to find out what makes these kids want to learn and how to maximize both learning and happiness at school. Vygotsky's work on the "Zone of Proximal Development" guides my work with children who need a little extra help—they are really smart kids, yet don't know it. Those same kids need a little bit of assistance at first but then later are able to solve the same problems as the child who understood it immediately.

Image 1. Students mix concrete for the bench foundations.

Csikszentmihalyi set out to explore what many people focus their lives on: happiness. In fact, he spent 25 years researching, thinking, and studying what elements compose the intense episodes of happiness that are seared into the memory of an individual, episodes which remind them of what life can be. He called this kind of event an "optimal experience" (Csikszentmihalyi, 1990, p. 3). He found that these times were not during the most relaxed, laid back, or passive moments of our lives, but during the moments when our minds and bodies are stretched to their limits, achieving things we never thought possible. We may be in great pain or under indescribable stress, and at the point where we are about to cave in and give up we break through it all and have an optimal experience.

During these times of optimal experience, a person may enter a state during an activity where he or she is so involved that nothing else matters and the person will continue to do the activity at any cost (Csikszentmihalyi, 1990; Csikszentmihalyi & Lefevre, 1989). Csikszentmihalyi found people of varied socioeconomic statuses engaged in this state of

flow in many activities from mundane chores to highly specialized operations—from a farmer's work in the field to a brain surgeon's operation. The activity itself did not determine whether a person entered a state of flow or not. What mattered was the person's relation and attitude toward what the person was doing, and whether the activity had components of challenge and complexity (Csikszentmihalyi, 1990).

Similarly, John Dewey (1956) in the early 20th century referred to a learning state as "spontaneous attention or as some say, non-voluntary attention" (p. 145). His description reminds one of a state of flow: "The child is simply absorbed in what he [sic] is doing; the occupation in which he is engaged lays complete hold upon him" (p. 145). When children are in a state of flow or spontaneous attention, we can teach them optimally, for they become reflective learners, who take the experience with them, think, explore, and problem-solve on their own.

Increasing the complexity of math content in a community-based program ignites many students' motivation to learn. This spark of interest then must be sustained by providing challenging, relevant, and open-ended problems for the students to work on over a long period of time (a few weeks to a few months). By slowly raising the difficulty of the problems, students must work a little outside their comfort zone, which initially causes anxiety. Moderate anxiety and challenge spur growth. Once the students rise to the challenge and master the skill, they may enter into a state of flow. Working through a large-scale project such as building benches allows the kids to immerse themselves intensely in something they can be proud of.

The Zone of Proximal Development (ZPD) is a concept named by Lev Vygotsky (1934/1986). It became popularized in the 1970s and 1980s. Many math researchers are using Vygotsky's theories to explain best practices for learning math and relationships, as well as the importance of communication in understanding math concepts (Goldstein, 1999; Middleton, 1999; Pape, Bell, & Yetkin, 2003; Steele, 1999.) The ZPD is the range between the mental age (or what a child can do independently) and what the child can do with assistance (Vygotsky 1934/1986). The students with a strong understanding of skills

Image 2. Students apply measurement skills to measure wood for one of the benches.

and concepts can assist those who are struggling to learn. In our class the students all learn together, our conversations about math improve meaning, and we all need help from time to time.

In a study of two children, Vygotsky (1934/1986) tested each one in mathematics and both students tested out with a mental age of eight. This means they could both complete math problems independently on an eight-year-old level. He then gave them problems that were beyond their ability level. They were given the first step in the problem, a leading question, or both. After the test, one child completed problems correctly at a mental age of 12 and the other a mental age of nine (Vygotsky 1934/1986). With a little help, in groups, many students can work at levels well above what they can do alone.

Thinking Things Through, Working Out What We Will Do

I took on this project to make our school a better place while teaching New Mexico state standards for grades 6, 7, and 8. I thought the standards of measurement and numeracy could be applied through the building of something for the school grounds. I asked each class what the school needed, and some of the suggestions included grass for the field, shade to protect them from the intense sun while at recess, and places for them to sit.

One day while I was outside on recess duty in late August, the sun was very strong on my neck and I noticed dust flying everywhere when the kids ran on the baseball field. Then I saw what needed to be done. When each team was at bat they stood behind the backstop, hung from

Image 3. Students use power tools during construction. Safety and skill mastery were carefully covered prior to beginning the project.

the backstop, or sat in the dirt. The kids had nowhere to sit. It hit me that a simple wooden bench could make this place better for the kids as well as the community when they come out to play games on the weekend. These benches could also be used for spectators of the cross-country meet—the finish line is within feet of the third-base side of the field.

The next day I went to the acting principal, and talked to her about what I wanted to do in math class. She told me the procedures for getting approval, which included checking for underground utilities, determining future plans for the space we would build on, and fulfilling safety requirements. She asked me to write up exactly what we would be doing and where the benches would sit and what materials would be used. I promptly put together a draft and gave it to her, and she began working with the people in charge of the physical operations of our school. On September 11, 2007, we had all the signatures we needed from facilities management. The next day I excitedly told all the students what we would be doing.

I sent out permission slips to all the parents clearly stating that we would be using tools that most kids in middle schools have never seen, much less used. I wasn't sure what skill levels they would have or whether they would want to do the project once things got underway. The use of chop saws, hammer drills, and other power tools caused me to worry. "What if someone gets hurt?" was a common thought that I tried to get out of my head as I worked with the class on safety and skill mastery prior to the project.

Why Build Benches? What Are We Ever Going to Learn From This?

The classes were finishing up a unit on numeracy, a New Mexico state standard, and would begin a lesson on measurement. The approval came in time to start the pre-assessment in measurement. I always tell the students that our first test on any math standard is for me to find out where they are and will not count against their grade. I do this to alleviate the stress of taking tests and as a baseline to see what they learned after the project is complete. I believe this gives the student a sense of accomplishment after mastering skills and concepts or even improving in math after the unit is complete.

I found in their first assessment that many of the students had a difficult time visualizing space and the place value of measurements. In our first activities, we used cut-up pieces of lumber that measured 1 inch, 6 inches, 1 foot, and 1 yard to get a clear visual of the value of each measure so they could estimate the height of a door or width of the hall. We then moved into the hallway where we used the 1-foot square tiles to measure the area of the middle school hallways including alcoves. We recorded these measurements on graph paper. We then measured each other with a tape measure and established ideal seat height, width, and length for the bench, based on an estimate of how many kids could sit on the bench at once. Then we decided how many benches we would need.

Once we exhausted measuring all the surrounding objects in the school we were ready to go to work on planning our benches. We returned to the math room and constructed prototypes with Lego-like square blocks. All were expected to build three miniature versions of the bench that they wanted to construct. They all learned how to brace the benches as well as leave openings in the structure for pressure relief from the fierce winds that hit New Mexico from

March until June. We talked about different materials we could use: metal brackets, rebar, concrete, and wood. We all voted on a design and drew it to scale on a piece of graph paper. At this point I began to believe we would finish the job.

We would build 4 benches (2 on the third base side, 2 on the first base side), that were 10 feet long by 1 foot wide. Our concrete footing would be 10 feet long by 2 feet wide by 6 inches deep. We calculated how many board feet we would need as well as the number of brackets and amount of concrete.

During the assessment I noticed the students understood half and quarter inches, and would round measures off when documenting what they did. After we measured our hallways repeatedly, this habit was beginning to go away. They started to work in pairs and could shout to each other things like "34 feet, 4 and ⅝ inches." When they calculated area, we would convert fractions of an inch over to decimals, which gave the kids a clear reason why they needed to know equivalent measures for fractions, decimals, and percents. This construction project would become a great vehicle for learning conceptual understanding and teaching the application of the state standards.

> No matter where you are in life, math is all around you.

We Learn the Same Math Concepts in a Different Way

"A lot of Native American boys need hands on; when they do it hands on, they see it different," said Marlene Kewanwytewa, parent of Marcus, a sixth-grade student who worked on the project. "Marcus will, in a sense, need to try it himself, then they learn it. Hands-on projects keep his attention." Working out math-based problems in the context of construction allows the child to see why we learn math. It directly applies what we need to learn and makes meaning for the child. According to Fernando Shije, a sixth-grade student, "Doing hands-on activities is my favorite thing to do because it is fun and I do better when it is fun."

The students became engaged when we worked out math problems that they saw as needed and helpful for the school. They were able to see why we need to learn math and exactly where it can be applied. "We needed benches around the baseball field, and I felt it was a good way to help our kids understand why math is so important," said Tammy Pino, mother of Angelina Pino, an eigth-grade student who worked on the project, "No matter where you are in life, math is all around you. The bench project just made it more clear how math can be applied to everyday projects." Catherine Calabaza, mother of Jenna, a seventh-grade student, agreed, "There are other ways to learn besides on a piece of paper. By measuring and working out the problem on a project, they were doing something special."

Math Projects Encourage Us to Work Hard As a Team

When I asked Jenna Calabaza, a seventh-grade student, what was her favorite part of building the benches she told me, "Cutting the re-bar." During the project, she must have spent a few minutes wrestling with the bolt cutter to finally cut through the ½-inch re-bar. "It felt good when it broke." Her comment reinforced what I have been thinking since the project ended, that when we are working hard and really taking on challenges, all of us feel good, accomplished, and proud. Catherine Shije said, "It really encouraged my son to do his best."

The most challenging part of the project was working as a team to measure each cut and line up holes for the bolts. "We measured everything a lot. Some person said one measure and another person said another, and we measured again to see if it was right," said Tristian Pino, a sixth-grade student. "It takes a lot of work and responsibility and teamwork to handle just one project." For example, we would measure the center of each 4x4 post at the angle iron sunk in the concrete, carry it across the field about 100 yards into the industrial arts room to drill the hole, then carry it back to see if it was right.

Image 4. A finished bench guards the third-base line.

Pride

All of the individuals I interviewed said loud and clear how proud the project made them feel as parents and students. Some relatives wanted their grandsons and daughters to build them benches to sit on to watch the dancing and to sit on during feasts. Earl Calabaza, father of Jenna, said, "I play on the field sometimes and those were real strong and tight benches. I looked for my daughter's name in the concrete. She did a real good job!"

Teacher Thoughts, Looking Back

I am so proud of what they accomplished. I was nervous when it came time to use power tools. I learned that we as teachers need to work through our times of uncertainty, and our moments of woe. We should believe that everything will work out. These kids absolutely astounded me with their ability to problem-solve on the worksite, work out differences, and come together when needed. I believe students need to problem-solve within a real-life, community-based context to truly understand the math concepts you are teaching them.

I am grateful to the community of Zia for supporting a project that at first might have been seen as crazy—kids and power tools! Every time I have taken a risk and tried to teach math in a different way the parents have backed me up 100%. The school is a success because of them. Many parents brought in shovels, drills, wheel barrows, and drill bits to help lower the cost of the project. The Zia School Board and Governor Ivan Pino supported the research and writing of this article, believing that these kids should be recognized.

I am also grateful to every member of the school staff. During the project many people came out to help. When we were running behind in the concrete pour, teachers and other staff pitched in and helped the students mix concrete. These people care a lot about the students they teach.

What I learned from this project is that when you give kids the respect and opportunity to do great things, they will. Kids will rise to the level you expect them to reach—and beyond. Watching them work, I had to put aside my fear of accidents and stand with them, motivate them, and expect that they will work through the difficulties that come with any project. We made mistakes and while making them learned about measurement, numbers, and construction. A year later these benches stand as strong as they did when we built them.

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