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Effective Teaching

Mathematics for the Alternative High School Student

by Janice Bussey

> *I have noticed an improvement in the students' intuitive thinking. Learning happens at many different levels. In one activity, some students may be grasping probabilities, while others are understanding adding fractions or converting decimals to percents for the first time. This is particularly valuable in our flexible alternative setting where we can adjust our pace or have students repeat certain sections.*
>
> *-Janet Johnson, Teacher at one. Achievement Community School, Stockton, Ca.*

When alternative high schools are trying to provide for the mathematical needs of their students, there are numerous challenges. Many students enter alternative programs with very low math skills. They have been unsuccessful in the mathematics program of their home school and have traditionally been turned off to math. There is also a wide range of math ability levels that often must be addressed in one self-contained classroom. As a solution, teachers typically focus on basic skills, hoping to at least get students to pass a basic proficiency level in arithmetic. At times, brighter students might work independently in packets or in an algebra text. But one would seldom see excitement or enthusiastic engagement in this type of a math program. Teachers do not have to settle for this approach.

The Interactive Mathematics Program (IMP) offers another option and a glimmer of hope for teaching mathematics to alternative high school students. Alternative high schools in the Middle College High School Consortium have been using IMP for the past four years. Two years ago, alternative schools in San Joaquin County started using IMP and the county now has ten of its schools implementing the program.

IMP is an integrated four-year core mathematics program intended as an alternative to the traditional Algebra I-Geometry-Advanced Algebra-Pre-Calculus course sequence. It was developed in 1989 by two mathematics professors from San Francisco State University and two math teachers and professional developers at the University of California's Lawrence Hall of Science in Berkeley (Introduction and Implementation Strategies for the Interactive Mathematics Program, 1998). After extensive piloting and field-testing, with feedback provided from both students and teachers, IMP was published in 1997 by Key Curriculum Press.

Teachers using IMP have found that a greater number of learners, including those with diverse learning needs, are achieving success with high-level mathematics. They have been able to get their students well beyond arithmetic in a way that the students can understand and enjoy.

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Why is IMP able to accommodate the needs of students who have been previously unsuccessful in mathematics? Here are five major reasons:

IMP recognizes diverse learning styles

Oftentimes in a traditional math classroom, the teacher relies on lecture to explain a concept or demonstrate a procedure. The students watch and then practice with guidance from the teacher. IMP brings in other learning modalities. Many visual models are used. Hands-on manipulatives are employed to teach integers, angle relationships, probability concepts, and the Pythagorean Theorem. Students move about to role-play, give presentations or reenact the multiplying of matrices or the transformation of linear equations. Pupils are continually asked to justify their thinking either through an oral presentation or with a written explanation. They are encouraged to use drawings, diagrams, or pictures. With all of this variety, those who do not have strength in logical/ mathematical intelligence can still learn since much of the curriculum draws on other intelligences (Armstrong, 1994). One community school student, while learning positive and negative integers through an experiment with hot and cold cubes, admitted, "I never thought about it that way; now it makes sense."

IMP uses open-ended problems and investigations that provide multiple entry points for students

Perhaps the best way to illustrate this concept is with a problem from the IMP curriculum. Figure 1, on the following page, shows a problem from *The Overland Trail*, a unit from the first year of IMP focusing on the foundations of algebra and linear relationships (Fendel et al., 1997). Students are asked to address several different scenarios concerning a brother and a sister who save their money to buy a calculator. They are encouraged to use equations and graphs, but it is not spelled out exactly how to use those tools to answer the questions. Most students initially approach this problem with an organized table showing how much money Seve and Jillian will make after working a certain amount of hours. Students are then able to attack the problem, analyze the situation, and answer the questions with any of the tools they feel most comfortable with . . . or even a combination of those tools. Some feel more comfortable with the numbers in their tables. Many are visual and gravitate towards the graphs. There are even a few who end up writing an equation to solve. The beauty in this lesson culminates when all of the learners come together and share their work. The teacher orchestrates the presentations and discussion so that the entire class experiences the multiple approaches. More importantly, she helps the students to understand the connections between the tables, graphs, and equations, and how they relate and address the story problem, an essential curricular component in mathematics and algebra (Cawelti, 1995).

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Figure 1

The Overland Trail — *Homework*

Homework 25 — The Big Buy

Seve and Jillian Vicaro want to make some money over the spring break from school. They ask their parents to let them work around the house to earn the money. Their parents agree, since Jillian and Seve are saving to buy graphing calculators. Dad tells Jillian that he will give her a starting bonus of $10, and then pay her $5 an hour for the work she does around the house. Mom offers Seve a slightly different deal. She will give him $40 to start but only $3 an hour.

1. Write two separate equations, one for Jillian and one for Seve, expressing how much money each has earned (including their starting money) in terms of time worked. (Use x for the number of hours worked and y for the amount earned.)
2. Graph both equations on the same set of axes. (Be sure you know which graph is for which person.)
3. If the graphing calculator costs $72, who will be able to buy one with the least work time? Explain your answer.
4. If the graphing calculator costs $100, who will be able to buy one with the least work time? Explain your answer.
5. For what price must the calculator sell in order for Jillian and Seve to earn that amount with the same number of hours of work? Explain your answer.

IMP increases student motivation by employing real-world contexts, humor, and emotion

Students need to see meaning and relevance in what they are learning (Jensen, 1998). Alternative high school students especially demand a rationale for what they are learning and how they are spending their time. The mathematics in IMP is presented in a wide variety of real-world contexts. In addition, the latest brain research supports that students learn more and retain information better if it is presented with humor and situations that evoke emotion (Sprenger, 1999). Many of the IMP problems might seem silly, but their fanciful nature makes the students laugh. They might make fun of Alice, who grows when she eats an ounce of cake and shrinks when she drinks an ounce of beverage (Fendel et al., 1998), but the story helps them to remember the laws for exponents.

IMP presents mathematical ideas that can be useful to the average adult, not just for the college-bound

In addition to meeting college entrance requirements, the program contains a large number of mathematical concepts that will promote informed consumerism, problem solving, and logical reasoning. These are just a few examples of the exciting contexts embedded in the curriculum:

- Sorting out important information, formulating sound arguments, providing counter examples, and recognizing faulty reasoning
- Learning to make decisions about what is fair and not fair
- Extending and generalizing mathematical patterns to determine what to do next
- Employing curve fitting to

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make predictions in a multitude of settings
- Learning about normal distribution and standard deviation so that students can understand statistics and sort through what is relevant and what is not (Introduction and Implementation Strategies for the Interactive Mathematics Program, 1998)

IMP uses a variety of assessment tools

Students are not always adept at demonstrating their learning with traditional paper-and-pencil tests (Frazier & Sickles, 1993). Although the latter do exist in IMP, the program allows students other ways to show what they have learned throughout a unit. There is both individual and group work. Students present their findings with oral presentations, written reports, active demonstrations, or with a finished product or personal portfolio at the end of each unit. Some of the written assessments are done in class, some at home, and many include reflective pieces where the student has to summarize what he/she has learned.

These five points can be illustrated further with a brief walk through one of the IMP 1 units, *The Game of Pig* (Fendel et al., 1997). The unit starts with a description of the dice game Pig. The game involves rolling a die and adding up points. The player rolls until deciding to stop or until a "1" is rolled. If a "1" is rolled, all of the points for that turn are wiped out. If the decision is made to stop rolling before a "1" comes up, the player gets to keep those points. The unit problem asks the class: What is the best strategy for playing Pig? In other words, how should you play in order to end up with the most points over the long run? The nature of the Game of Pig and the fact that students get to play with dice provide instant interest and motivation. The analysis of the game involves probability; thus the unit begins with an introduction to probability by presenting a variety of scenarios where different principles and probability tools are developed. This is a perfect time for the classroom teacher to review fractions, decimals, and percents, since they are necessary for dealing with probability. Alternative high school students need this review and these skills show up on many standardized tests. While the students have certainly seen this content before, the Game of Pig provides students with a new impetus. They now have a reason to learn how to manage fractions, decimals, and percents. They can see where they are used and they realize that they will never be able to analyze the Game of Pig without them.

Still, finding the winning strategy for the Game of Pig is a *big* problem. So, like in many other IMP units, the students take a look at a smaller problem: Little Pig. This game involves a bag containing three cubes--one red, one blue, and one yellow. In each turn, the player draws a cube as many times as he wants (replacing the cube after each draw) until he either decides to stop or he draws a yellow cube. Each time he draws a red cube, he gets one point. Each time he draws a blue cube, he gets four points, but drawing the yellow cube wipes out his points. Once again, the students have to find a strategy for Little Pig that will give the highest possible score in the long run.

Groups start out playing Little Pig, developing strategies, testing them, and getting a sense of which strategies give them the most points. This activity is tactile and emotional. Students enjoy playing the game. Motivation and interest is increased. Over the next few days, students test other groups' strategies

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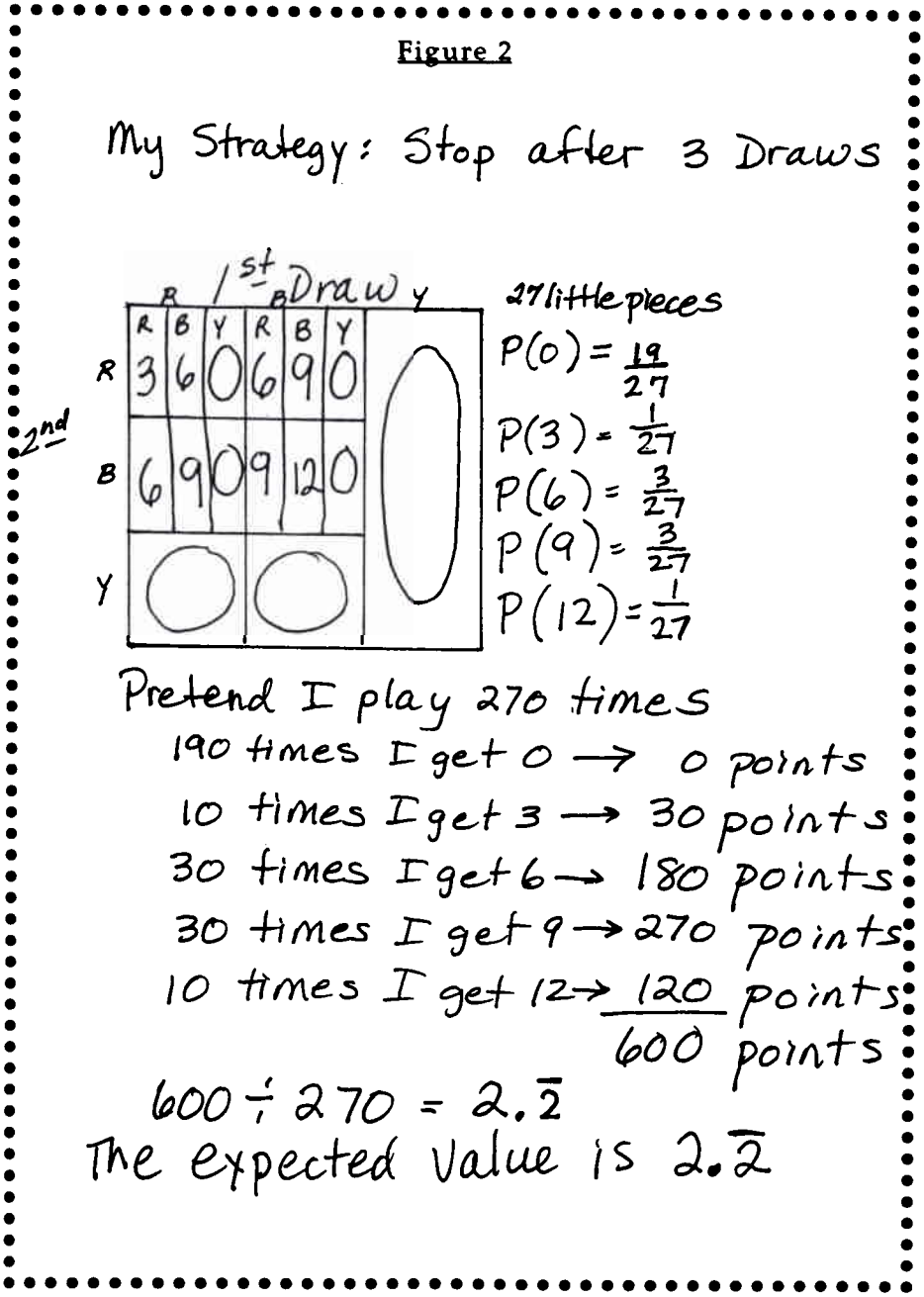
and eventually analyze the strategies using an area model and the principle of expected value. Figure 2 below shows one student's work for analyzing the strategy of stopping after three draws. By studying the expected values, students can find the best strategy for playing Little Pig. They extend these principles to the big Game of Pig and solve the unit problem.

Figure 2



Reviewing fractions, decimals, and percents, learning about probability, and handling a sophisticated concept like expected value has a lot of mathematical merit. Teachers are pleasantly surprised that their students can accomplish much more than expected. Still, students need to see where these concepts and skills are useful outside of schools. Figure 3, on the following page, shows an assignment from *The Game of Pig*, which applies the students' new knowledge of probability and expected value to the lottery and to the notion of buying insurance. Students enjoy discussing the realities of these issues because they come up in their day-to-day lives.

Teachers using IMP with alternative high school students have found that their students can actually do some very high-level mathematics and be successful. But implementing such a program is not without its challenges. Teachers in these settings have not been able to progress through the units as rapidly as the course was intended. With a population that is struggling academically, these instructors have frequently found that they have to pause and review basic skills. Many schools still

struggle with the nature of homework, while some have a culture where homework is expected. The IMP curriculum was written with daily homework assignments. Often, the teachers have had to use some of those critical homework assignments as class work, and that means it takes even longer to get through a unit.

On the bright side, it *is* possible to pick and chose IMP units so that the most important concepts are covered in the first year. It is reasonable to get through three units a year even with the stated challenges. Teachers like to use the first IMP unit, *Patterns in Mathematics*, to introduce students to the nature of this math program and to orient them to some of the basic tools of mathematics: problem solving, in/out tables, patterning, graphing calculators, and integers. In this unit, students are also introduced to the idea of justifying one's thinking through written expression and oral presentation. There are also group-building skills that are taught and developed in this first unit (Fendel et al., 1997). *The Game of Pig* follows *Patterns in Mathematics*. It presents an environment to

Figure 3

The Game of Pig *Homework*

Homework 18 The Lottery and Insurance -- Why Play

This assignment looks at two real-life situations that involve probabilities to see if expected value tells the whole story.

1. The Lottery

Many states raise funds through various lottery games. (If your state has one, you may want to learn more about how it works and what happens to the proceeds.)

Assume that each lottery ticket costs $1. The number of tickets sold and the value of a winning ticket often vary from week to week. Suppose that, for a certain week, about 14 million tickets were sold and that the winning ticket is worth $6 million.

a. Calculate the approximate expected value of a lottery ticket that week.
b. Do you think buying a lottery ticket is a wise investment? Explain your answer.

1. Insurance

Buying insurance can be thought of as similar to playing a lottery game. You pay a certain amount, called the *premium*, every month to the insurance company. Most of the time, the insurance company just gets to keep your money, and they pay you nothing.

Sometimes, however, you have a claim that is covered by insurance. When that happens, the insurance company has to pay your expenses (for a car crash, illness, fire, or whatever that incident is), and they generally have to pay you much more in that month than you paid as a premium. So, in a sense, you "win" whenever you collect on your insurance. This means that the "insurance game" is a game that you don't really want to win.

In the long run, insurance companies take in more money in premiums than they pay out in claims, or they wouldn't be in business. In other words, their expected value in the insurance "game" is positive, and yours is negative.

So why do people play?

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review basic arithmetic skills while developing higher level skills in critical thinking, probability, and expected value. Finally, in that first year, it's important to get to *The Overland Trail* for the opportunity to lay the foundation for algebra (Fendel et al., 1997).

Professional development is critical when introducing the Interactive Mathematics Program in alternative high schools. Many teachers in alternative high schools are generalists. They teach multiple subjects to all students and math is not always their strength. With IMP, they are teaching mathematical concepts that might be new to them as learners. One community school teacher, Deb Nickols, stated, "I often think I get more excited than my students because I am now beginning to understand the old rules I memorized long ago. IMP does make teaching (and learning) math fun. It makes math make sense!"

Training should be combined with pedagogy and the modeling of exemplary instructional strategies. Professional development and additional training should continue throughout the school year and should include in-classroom coaching and support. With such time, energy, and resources, the students will end up being the beneficiaries with increased knowledge in mathematics and increased options about what they are able to do after high school.

About the Author:
Janice Bussey is a Math Specialist for the Tracy Unified School District. Additionally, she has provided professional development to math teachers in alternative high schools.

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