Using Science to Promote Preservice Teacher Understanding of Problem Solving in Mathematics

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Abstract

Preservice elementary teachers need to be given the experiences of integrating mathematics with other subjects. They need to go into the classroom with the understanding that mathematics is not an isolated topic. This article describes a paper airplane activity that was presented in a class of preservice elementary education teachers to show how mathematics and science can be integrated with one another.

Problem solving involves more than just solving word problems presented in a textbook. As NCTM (2000) suggests:

> Students can learn about, and deepen their understanding of, mathematical concepts by working through carefully selected problems that allow applications of mathematics to other contexts. Many interesting problems can be suggested by everyday experiences, such as reading literature or using cellular telephones, in-line skates, kites, and paper airplanes. Instruction should take advantage of the expanding mathematical capabilities of students to include more-complex problems that integrate such topics as probability, statistics, geometry, and rational numbers (p. 256).

For preservice teachers, it is especially important that they understand that mathematics presented in a problem-solving context, gives meaning to the mathematics at hand and can be used as a motivation tool (Sharp and Adams, 2002). To facilitate the integrated approach to problem solving, as NCTM suggests, I presented a mathematics lesson that incorporated science in a math content course for elementary and exceptional education majors. This course has an emphasis on proper use of hands-on activities as pre-service teachers learn the mathematics content.

Introduction

I announced to my class of 26 preservice teachers that we would be having a paper airplane contest. Many of my students questioned how flying paper airplanes had anything to do with math. Without giving any answers for this question, I continued with the class by explaining that their task was to create airplanes for two contests. One airplane would compete for the longest distance traveled and the other for the longest flight time. The limitations were that each airplane could only be made from the provided one 8 ½ x 11 sheet of paper and one paperclip. The paperclip for each plane was made optional. Everyone only had 30 minutes to create the airplanes they would 'enter' into the contest. With that said, the students got into groups of 3 and proceeded on with the activity as they saw fit. Also, I gave each student the following list of questions to think about while they were doing this activity:

Mathematics: Think about what properties the plane must have. Ask yourself the following types of questions: What sized wingspans make your plane fly the farthest? Does a larger or smaller plane stay in the air longer? Why?

Science: Formulate a hypothesis about each plane. Create a plane based on that hypothesis and test it out. Draw a conclusion based on your test results, and make adjustments to the original plane as needed. Figure 1 has been designed to help you organize your data.

It's important for students to understand the science behind an activity like this because it provides another solution method to problem solving in mathematics (testing and refining data before arriving at a final solution). In addition, Frykholm and Glassen (2005) found that mathematics content is often taught in isolation from other topics that may have provided various contexts and/or connections (p. 137). By not integrating mathematics with other disciplines, teachers will miss the opportunities to watch students explore mathematics in a new way. As with an activity, such as this, more than one solution method was used to solve the given problem. The class used trial-and-error and was also introduced to using data collection in mathematics (see Fig. 1).

Fig. 1
Record the data from each paper airplane

Plane	**Approx. Distance**	**Approx. Flight Time**	**Plane Thrower**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Groups were told to keep track of who threw the plane because that could be a contributing factor to how well the plane performs. Also, I only provided the class with colored paper and paper clips. Students were not given any sample airplane patterns to look at, because I did not want every group to end up making the same plane. In addition, their plane would not be unique to them if they were exposed to sample airplane patterns. Throughout the activity, I never had any students ask about sample plane patterns and/or pictures.

Activity

Once the activity started, I had students coming up and picking out several sheets of paper in their favorite color. Within minutes, groups were up and testing various airplane designs in the classroom and out in the hallway. Walking around and informally assessing what students were doing and how, I noticed that every group immediately started a trial-and-error routine. Individuals in each group made around 3-planes each, so that each group ended up with approximately 10 planes to test. When introducing this activity, I thought that students would take a more systematic approach when making their airplanes.

Within the first 5 minutes, a student asked if they could use the same plane for each contest. Their underlying assumption was that the plane that flies the farthest distance would automatically be the plane that stays in the air the longest. Before I had a chance to respond, another group member explained that a plane could technically be shot straight in the air, stay in the air a long time, and not travel a great distance. Likewise, a plane that travels a far distance could do so quickly, thus not stay in the air for very long. Once every group member realized that this was true, they quickly turned their focus to solving the longest distance problem first, rather than trying to do both tasks at the same time.

When creating planes, groups chose to isolate themselves from one another. Two of the groups did have a mini contest with one another, but this was the only collaborative effort done between groups. The planes that groups created varied in design depending on the specified task they were creating it for. The airplanes made for the distance contest were long, thin, and had a paperclip on it either in the front or the back. For longest flight time, groups had created airplanes that were shorter and wider than what they had created for distance. Only one group had figured out that a lighter plane stays in the air longer, so they were the only group that elected not use a paperclip on their plane. This group ultimately won the flight contest.

When testing their airplanes, students were provided with materials to help them keep accurate data for each plane. Tape measures and yardsticks were provided for each group to measure the plane's distance. Since I did not have access to a class set of stopwatches, students were using the stopwatches on their cell phones to time how long the planes stayed in the air.

After students had tested out several planes and started to eliminate certain plane designs, more in-depth conversations started taking place. Discussions evolved around justifying why one plane flew a longer distance than another. One group in particular looked at the plane design. They discussed why the longer thinner plane traveled farther over the others. Aerodynamics was a focus of that group's discussion as they realized that the longer thinner plane displaced air more as it flew, thus made it fly farther. This group also discussed the placement of the paperclip and how that would affect the distance the plane traveled (whether it was more beneficial to place the clip at the nose of the plane or the back of it).

Once all of the groups selected the 2 planes that they wanted to use in the competition, I divided the class in half. Half of the groups did the distance contest first, and the other half did the flight time contest. Students were asked to keep the data from every group so that they could compare planes after the contest was over. To do this, everyone recorded the following table onto another sheet of paper (see Fig. 2).

Fig. 2
Record the longest distance and longest airtime for each group

Group	Longest Distance (Out of 3 trials)	Longest Air Time (Out of 3 trials)
1		
2		
3		
4		
5		
6		
7		
8		
9		

Every group was given 3 tries to get the longest distance traveled and 3 for the longest flight time. One person was selected from each group to throw the plane for each competition. To limit the amount of time it took to measure the distance, the group members that were not throwing the plane stood where the plane landed. If the plane landed a farther distance away the second or third time, that person moved, so that only the longest distance was measured as opposed to 3 separate measurements for every group. For data purposes, only the longest distance was recorded, so the other two shorter distances did not matter, and thus did not need to be recorded.

Contest

A tape measure was given for students to measure how far the plane flew. Since stopwatches were not available, the students who had stopwatches on their cell phones lent them to the groups participating in the flight time contest. For the distance contest, discussions ensued around how to measure the distance. Some planes curved as they flew. Several of the groups immediately questioned how to measure how far the plane traveled. The question posed by several students was "Do you measure how far the plane flew taking its curvature into consideration, or measure its distance by creating a 90 degree angle with the starting point?" The Pythagorean Theorem became a factor within the actual contest, because groups noticed that the distance would be longer, if you took the plane's curvature into account (see Fig. 3).

Table 1 provides the data collected for each contest from 5 of the 9 groups. Since I was more interested in students' responses to the writing prompts (discussed in the next section), students were not required to turn in their contest data. Though every group completed the activity, only 5 groups turned in their data at the end of class, which is why not every group is accounted for in the tables.

Fig. 3
Calculating paper airplane distance from target

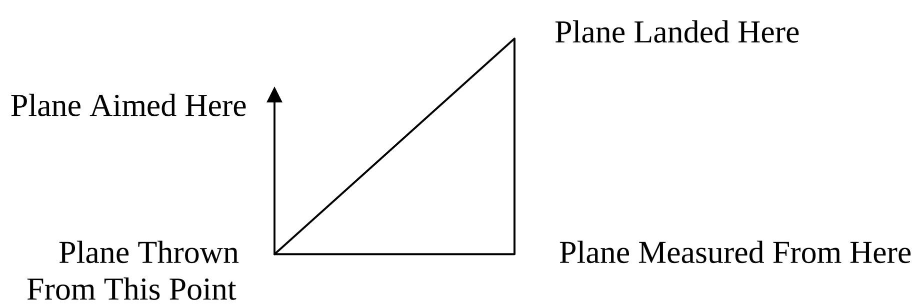

Table 1

Best Distance (Out of 3 trials)	Best Time (Out of 3 trials)
16ft 10in	2.81 sec
10ft 4in	1.75 sec
47ft	2.00 sec
18ft 3in	3.05 sec
10ft .25in	2.58 sec

Responses From the Preservice Students

After the contest was over, each student was given the following list of prompts to answer.

1. How did your group go about creating your two airplanes? In other words, what was your solution process? What problem solving strategies did you use?
2. What conversations did your group have as you were creating your airplanes?
3. How did your group finally decide on the final planes that you created, and why did you feel that they were good enough to win? What properties did your airplane have?
4. Analyze the winning team's plane for farthest distance. Why do you think their airplane traveled the farthest? What properties did their airplane have that were both similar and different to your group's airplane? If you won, why do you think your plane went the farthest?
5. Analyze the winning team's plane for longest flight time. Why do you think their airplane stayed in the air the longest? What properties did their airplane have that were both similar and different to your group's airplane? If you won, why do you think your plane stayed in the air the longest?

These questions were not discussed in a whole-class setting. Rather, I had everyone respond individually to these questions. The following are responses I received for each question:

1. "We asked if anyone had techniques, each made one, then we kept modifying the best."

   "Made random planes and did test runs. Our solution process was to turn the paper clips into 'spoilers' by untwisting them and attach them to the plane. We tested the two with the farthest distance and time against each other to pick the best plane."

   "We each created different types of airplane, doing a process of trial & error. We folded certain ways & tested it out, deciding which plane would best fit for the contest."

2. "A long and skinny size seemed to fly best and putting the paper clip near the front gave the planes a straight path."

   "As we were making the planes, we were discussing the different sizes that we could make the planes, the different ways of making planes, where the paper clip should be placed (tail, middle, front), and the different colors being used as identifiers."

3. "The longest streamline plane flew the furthest. The short planes wouldn't fly a long distance. The plane with a long streamline and different folds in the wingspan floated and flew the greatest amount in the air."

   "We choose the only plane that flew long & skinny."

   "We decided on the plane with the best test run. We had a fly off with the other team at our table. Properties included pointed nose, broad base, triangular shape with two points at the rear."

4. "The winning team was our team. Our plane went 47 feet. I think our plane went the farthest because we made it like a jet, and we make our front pointie. So that is why I think it make it the farthest."

   "Very clean lines which are good to be streamlined. They had skinny wings like ours. It is different because their paperclip was on the tail."

   "I think the plane that traveled the farthest had enough bearing & creases to glide through the humid air. In some ways, the planes were similar b/c each were folded long ways but different in that the winner's plane's creases were mostly folded in ways rather than out."

5. "No paperclip, the wings are trimmer and towards the back instead of more front. I think that it stayed b/c it didn't have a paperclip."

   "Our plane flew the longest time. The wingspan was large and the plane was light allowing it to stay in the air longer."

   "I think the airplane that stayed in the air the longest had a lot of surface area. The airplane was folded hamburger way & created enough surface to stay in the air longer than our plane, which was folded & creases long ways."

Comments

When first introducing this activity, many students did not understand how paper airplanes had anything to do with mathematics. One might question whether or not making and flying paper airplanes as a component of a mathematics and science lesson constitutes meaningful instruction (Frykholm et al., p.135). Without answering the questions at the beginning of class as far as how math plays a role in this activity, by the end of the activity, students had discussed everything from aerodynamics, surface area of the wings, and weight of the plane, to the Pythagorean Theorem.

Groups had varying conversations depending on their difficulties with the task of making a paper airplane. Even so, each group came to very similar conclusions regarding why the winning planes performed better than anyone else's.

Throughout the whole activity, no one mentioned symmetry and how that affected their plane. For a plane to fly straight, it must be symmetric from its nose to its back. It also must be weighted the same on each side. Only one group mentioned that having the paperclip at the front made their plane fly straight. They even still did not discuss how symmetry played a part in that flight path.

References

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