# Exploring Angles by Making Paper Airplanes

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## Learning from Students

I introduced the task of making paper airplanes using angles in a Grade 6 math class with 16 students, 8 of whom had special needs. The students used various types of paper to compare how far the planes flew and noted if paper weight influenced accuracy of flight. They used rulers to design the airplanes and geometry sets to identify the angles when they were labelling them. A metre stick was used to measure the distance the airplanes flew. Students used templates to estimate, identify and categorize angles and to fold paper into airplanes and test flight. They used a distance chart to record, compare and analyze each plane's flight and features.

For this paper, I focused on the two students that stood out the most to me, both boys. I will refer to them as Paul and Jim. Paul appeared to be an advanced student; he knew his angles and was able to answer all of the questions. Jim was a special needs student who really struggled with the mathematical words and estimation of angles.

The lesson was 80 minutes long. I began by reviewing angles by writing on the board "What are angles?" I drew a picture of each of the angles—acute, right, obtuse, straight, reflex, and circle—and marked the angle I wanted them to solve. In a class discussion, I asked the students to tell me what each angle was called and why it fit into that angle classification by estimating the degree of the angle. I asked these questions:

- Can you tell me what each angle is called?
- How do you know it is called that?

Paul knew that the angle was called acute because it was smaller than the right angle and that the obtuse angle was bigger than the right angle. He knew that the other angle was 180 degrees because it was a straight line. He was able to articulate that right angles were always square and were 90 degrees and that 360 degrees made a circle, so the reflex angle had to be between 180 and 360 degrees.

Jim had a much more difficult time. He didn't know what that angle was called, and he couldn't remember the vocabulary, but he identified that one angle was bigger and the other smaller than the right angle. He didn't know that a straight line was an angle or that if an angle goes all the way around it makes a circle. Jim was able to recognize the right angle and the acute and obtuse angle when he used the right angle as a reference.

- Using estimation, what degree is each of these angles?
- How do you know you're right?

Paul was able to identify that the acute angle was 45 degrees because it looked like it was half the size of a right angle. He thought the obtuse angle was 135 degrees because it was half again as much as the right angle, and the reflex angle was half again as much as the straight angle. Paul already knew how many degrees a straight line and a circle are, so he was able to use that as a reference for the reflex angle. I drew the reflex angle at 270 degrees, so he was also able to use the right angle as a reference.

Jim knew that the smaller angle had to be less than a right angle and that the bigger angle was more than the right angle. I asked Jim how he could use the right angle to figure out the other two angles. Jim thought for a bit and then said he could draw a pretend line for a right angle and then add to make it bigger or subtract to make it smaller. He was still unsure about estimating a number. I asked Jim to use a piece of paper and fold the corners to make a right angle and then fold it in half again. Jim was able to see that the acute angle he just made was half of 90 degrees. He was then able to take half of 90 and make 45. Jim was able to connect angles to making paper airplanes.

After we were finished our discussion on angles, the students labelled the angles and degrees on a template. I threw a regular piece of paper into the air to demonstrate that a piece of paper cannot fly without angles. Then I had the students design their own paper airplanes. When they were done, they competed against each other to see whose design could go the greatest distance and whose design had the best accuracy. After we were finished flying, we discussed why some designs worked better than others and how angles make a difference.

## Reflecting on the Work

I was really surprised by Jim. He struggled with estimating the angles; however, his design won first place in both distance and accuracy. His plane flew three times farther than the plane that came in in second place. He was also able to explain why his design won. This was really unexpected, and I was very impressed. Jim understood the concepts of angles and flight but needed help breaking down the angles to figure out the degrees.

Paul, on the other hand, was able to use strategies and reference points for estimating angles. However, it was more difficult for him to make the connection between angles and flight. He was not able to explain how he could improve the design of his paper airplane, although he could explain how angles affect flight.

Having a class discussion on angles before having the students label the template worked really well. The students would have been lost and confused without a class discussion. As we discussed angles, I could see the students light up when they were remembering how to label and estimate. It would have been an impossible task without the discussion.

In many ways I think my task would have been easier to conduct if I had been working with only two or three students instead of such a large group. I had to adjust my task as I went along so that it could accommodate so many students with special needs. One of the downfalls was that I needed to be able to help all of the students in the class instead of just focusing all of my time on Paul and Jim. In a smaller environment, I would have been able to ask more in-depth questions as I assessed the boys' thinking. I also would have been able to keep it closer to a 30-minute time frame.

The students could not remember very much about angles until I started asking questions. I think that the communication went well. The students were able to learn from each other and share ideas through the discussion. I was able to get all of the students to participate by asking them to show me using their arms what a particular angle looks like. Even if some of the students could not remember what each angle was called or what it looked like, they were able to copy the other students with the positioning of their arms. This helped trigger everyone's memory and was a huge icebreaker; it also encouraged more students to participate in the conversation.

The mathematical language was tricky for some because not everyone understood the meaning of *acute*, *obtuse* and *reflex*; some also forgot that a straight line was also a straight angle. This is where using the positioning of their arms came in handy. The students were quickly able to relate the angle names to the positioning of their arms. This helped them to recognize the angles when they saw a picture of them.

The students knew that the paper was not going to fly without angles. After they finished making and flying the paper airplanes, we discussed how the angles affected the flight. The students mentioned how folding smaller angles and making the plane narrower made it fly farther. The larger angles and bigger wingspan helped the plane stay in the air longer. They also discovered that some designs caused the plane to do loops or fly back to them. When we finished discussing paper airplanes, I asked them if they could think of any other ways that angles are used and who uses them. I got a lot of different responses: building houses and sheds, carpenters, electricians, hunters practising shooting clay pigeons, and playing pool. I think that the students understand the concept of angles and the importance of angles in real-life situations. By understanding the operations and relationships, students will be able to connect to other areas in mathematics. Knowing relationships is essential when learning addition, subtraction, multiplication and division.

One modification I could make would be to have the students label a premade airplane rather than having them label a template. They could take it apart, label it and put it back together. This way they could see the actual angles that are being used in that particular airplane. They could test the flight and see how the angles affect its flight. The students could do the same thing with a different premade airplane and then compare the angles between the two airplanes. This would give the students a visual reference to the differences that angles make in how the plane flies. They could continue working on improving the design of the plane to get the results they want.

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*Tricia Vadnais completed her BEd in elementary education at the University of Alberta in 2013. This article is based on an assignment in a mathematics education course she took during her last year of studies.*