

## **Lesson five: Airplane and error form**

### *This lesson's thinking patterns*

This lesson, which mainly covers practical and analytical thinking, is about something children love doing from an early age: folding paper airplanes.

**Practical thinking** – This is a good lesson to discover hidden talents in your class! There are always a few kids who know a great deal about flight and airplanes (practical thinking), and who are excellent at explaining to their fellow students what needs to be changed in a model that's not flying well.

**Analytical thinking** – The students will get caught up in folding and trying out their airplanes. However, the most important part of this lesson is the group creation of “error forms”. Here, students are forced to think analytically: they must evaluate their products, and together, come up with worst-case scenarios and fixing anything that might go wrong. In our experience, especially children with a fear of failure benefit from this lesson, as this time, it is okay for things to go wrong. That is an automatic part of the process of improving one's design.

### **Preparation**

When things are being thrown around, it is especially important to have clear rules for the class, so that the students can work in a relaxed and focused manner. Our most important rules: *nobody* can just throw a plane to try it out. If you want to try out your airplanes, you must ask the teacher first, and when you have permission, there is a corner of the classroom where one student at a time can try out their plane, aimed at the wall – *not* the classroom!

When trying out the designs, the group is lined up along the long walls: the student who is throwing is in the middle of one of the short walls, and their goal is to hit the opposite short wall with the plane (you can draw or hang up a bulls eye or goal lines on that wall). This will also help determine whether the airplane flies straight.

You may choose (to save time) not to write the errors on the blackboard. In that case, you can just hand each student a copy of the Error Form in the Questionnaires. This Error Form is the Questionnaire for this lesson, and every student fills it out, consulting with the others.

### **Lesson plan**

Students first work individually, and then in self-formed pairs.

You'll need:

- Sheets of A4 paper to fold the planes

- A room in which the planes can be tested – the gym, the hallway, a part of the classroom...

## Assignment

Fold a *great* airplane from a sheet of A4 paper. Use your own favorite model or use ours, for which you'll find instructions at the end of this lesson. When all models are done, we'll observe a test flight for each plane. Then we'll note all the things that can go wrong.

Then we'll proceed in two different ways:

- In pairs, you'll make an improved airplane
- With the group (everyone does a bit) we'll make an Error Form for paper airplanes that will help everyone: on one side, it lists all the things that can go wrong, and on the other side, it lists the things that can be done to solve these issues.

**Round 1** – Give every student a sheet of A4.

Together with the students, fold the paper plane described at the end of this lesson, or, if a student wants to make a different plane, that is fine too.

Explain to the students that there will be two trial periods, where the models will be judged:

Round 1: students take turns to show test flights of their planes; the group observes and notes which planes perform best (fly straight to their target). If you do this inside, let the student stand with one foot to the wall of the classroom, and tell them exactly where the plane should strike the opposite wall.

After round 1, the students whose planes performed poorly, can partner up with a student whose plane performed better. This way, students form pairs. These pairs will make a new and improved plane together (they must be able to indicate who contributed what afterwards!).

Round 2 – Now the pairs of students present their new models, and any errors that happen (something going wrong in flight) are reported.

Now, every pair is assigned one or more errors to solve. They will get about 10 minutes for this. Then, problems and their solutions are presented to the group by the pairs, possibly along with a demonstration. If the group agrees with the solution, it is written down on the board.

On the blackboard, there is now a complete error form with errors that can happen with a paper airplane along with possible solutions to the problem. This error form is typed out

and given to each contestant. At the end of the lesson, after the instructions for folding a plane, you'll find an example of an error form with explanations, and along with the Questionnaires there is an error form without explanations. You can copy this form and hand it out so that the students can fill it out themselves. This error form replaces the questionnaires used in other lessons. The students can now consult with each other to find solutions for the error forms.

## **Observations**

This is the lesson in which quiet kids suddenly turn out to be airplane-virtuosos. Give them a chance to introduce the group to their knowledge and see if they can explain their knowledge effectively (analytical thinking), and if they know how to keep their friends interested and persuade them (practical thinking).

Making and filling out the error form is the actual point of this lesson. It takes analytical thinking: evaluating the situation, thinking logically, naming problems, and explaining solutions. The practical thinking is important as well; having a feel for the material, working in a goal-oriented way, collaborating to find a solution.

## **Discussion**

Error forms are also useful in very different situations. Students will know more examples, in instruction manuals at home (for their TV or computer).

In class, error forms are useful too – for project groups and the like.

Let the students think of things that can go wrong in group projects, and what could be viable solutions to the problems. Let them use their own error forms in the next lesson.

## **Folding an airplane – instructions**

Fold your own favorite plane or follow our example. NOTE: For a good paper airplane, it's very important to work in an extremely precise manner. To make the ultimate plane for this challenge, this is even more crucial!

Make sure the folds are very sharp. Use a pencil to sharpen them if you're unhappy with the result otherwise.

Take a sheet of A4 paper. Fold it along its length.

Place the folded sheet in front of you.

Fold the two top corners down against the middle fold.

Turn over the paper.

Fold the top point downward.

Turn over the paper again.

Again, fold the two top points down against the middle fold.

Fold the sheet closed along the middle fold.

You now have two choices for finishing your airplane:

Option 1: Fold the ANGLED TOP SIDES down against the middle fold. (Be careful: on the top, there is now a lot of folded paper. So it will be difficult to make the final fold a sharp one. Use a pencil to rub it down if you can't do it with your fingers.

Option 2: Fold the STRAIGHT SIDE down against the middle fold. (Did you notice the amount of times we urged you to be very precise in your work? It wasn't often enough! It's THAT important to work very precisely.)

When you're done, test out your airplane by grabbing it about a third of the way from the pointy end in the bottom, then throwing it at eye level, aimed slightly upward.

### **Error Form Airplane**

(Worked out example)

Error 1 – The plane flips upside down in flight, then continues on.

Explanation – The wings of a bird (and of most planes) are always tilted up a little bit where they meet the fuselage. The same goes for your paper airplane. It should look like this from the front:

And not like this:

Why is this? Flying is a matter of air currents. Look at your plane: the center of weight (where most of the folded paper is) is in the front of the plane. Air must be pushed away from there, which only works if the wings are tilted up a little.

Try it out: a plane with flat wings will immediately flip over and crash.

So the Error Form contains the following:

Error 1 – The plane immediately flips over and flies on awkwardly.

Solution – Fold the wings slightly upward; they must point up at an angle from the fuselage.

Error 2 – The plane doesn't fly straight but veers off to the right or left.

Solution – Look at real planes: when a plane makes a turn, a flap will rise over one of the wings.

So: if you don't want your plane to turn around in flight, make sure that one of the wings isn't higher or lower than the other: they must be exactly equal.

The perfect (paper) plane is entirely symmetrical. The same goes for most normal planes.

Error 3 – The plane immediately makes a sharp dive and crashes nose-down into the ground.

Solution – This happens very often with paper planes. To solve this, you must create small flaps on your wings by raising the rear part of the wing up a little bit, like the flaps on a real plane. When air currents push on the plane, they will push down the rear, and so push up the nose a bit, preventing any more dives!

Error 4 – The plane goes up and down in a strange diving flight.

Solution – Now, you made the flaps on the wings a little too pronounced – you folded them up too much, so the air doesn't flow over it smoothly anymore, causing the plane to tip over. Gently fold the flaps down a bit.

*Think about the most important principle: symmetry!* Make sure your airplane looks exactly the same on the right and left sides.

Error 5 – The plane flops around in a corkscrew motion and falls down before your feet.

Solution – Symmetry! Have another look to see if the wings on the right and left side are *exactly* identical.

HINT: When you've thrown a good paper airplane a few times, you have to freshen up the folds, keeping everything symmetrical and pointing in the right direction. With every landing, the paper will change shape a little bit.