ENGINEERing challenge workshop for science museums in the field of aeronautic engineering

This document is produced under the EC contract № 288989

Index

Workshop ID card 3

Specific unit objectives 4

Resources 4

The workshop 5

Introduction 5

The main activity 6

Conclusion 8

Information for the facilitator 9

Background information 9

FAQ participants can ask 11

Problems you can encounter 11

Tips & tricks regarding the materials 11

ENGINEERing challenge workshop in the field of Aeronautic Engineering

Workshop ID card

[**Name of the workshop:** High Flyers

The Challenge: Build a glider capable of flying through a hoop

The Engineering field: Aeronautic Engineering

The science field: Forces

Target audience: Families with children from the age of 7+ years old or participants in schools aged 10-12 (as fewer adults to support)

Type of activity: workshop but could be run as a drop in with some adaption

Duration of activity: 90 minutes

Specific notes: You need to be able to set aside a large area for testing

Context

This workshop consists of a short briefing followed by instructions for making a variety of paper aircraft (a mixture of traditional planes and other shapes). The briefing is is designed to introduce the Engineering Design Process and the main forces involved in flight. The participants then build and test a variety of aircraft to see which one is most suited to fulfilling a specific challenge.

An introduction to the workshop challenge and the Engineering Design Process

- An illustrated presentation about the forces on an aircraft in flight and how to adjust the flight path of paper aircraft
- A demonstration of how to make up to 5 different types of paper aircraft
- A challenge to see if they can create a paper aircraft which can fly through a suspended hula hoop 3m (and optionally 5m) away

This workshop is designed to run as a separate timetabled workshop for 90 minutes where participants come in together at the beginning and get all the information in order. We also assume that when in family groups children will be working with adults (usually parents/grandparents) who will help them when needed.

It would be possible to adapt the workshop by removing the introductory briefing , so that it could be much more of a 'drop in' activity for children without adult support. This format would probably require more helpers.

Maximum number of participants: 30-45, including adults
Number of facilitators (intern): **2 (could be run with one person if fewer participants)**
Location: **Separate room in museum**
Set up time needed: 45-60mins

General objectives

The Engineer Museum Activities:

- ✓ Offer the participants an opportunity to find and experiment with different solutions to solve a "real" engineering problem
- ✓ Give a new perspective on Engineering as a field, a process, a way of thinking and working
- ✓ Introduce and exemplify the EDP (Engineer Design Process: Ask, Imagine, Plan, Create, Improve), or part of it
- ✓ Give the participants the opportunity to reflect on what they have done and how engineers work.
- ✓ Are based on IBSE - Inquiry Based Science Education and are not gender oriented.

Specific unit objectives

- ✓ To increase the understanding of the participants of the forces involved in flight
- ✓ To allow participants to make and test several different paper aeroplanes
- ✓ To allow participants to refine their designs until an objective (flying through a hoop) is achieved.

Contact Person

Natalie.Ford@scienceoxford.com

Resources

[List with all the materials and quantities for 20 participants, do not forget tables, chairs etc, at the end of the document there is room for more detailed information about the materials (the museum partners have to arrange the materials and maybe you have tips & tricks]

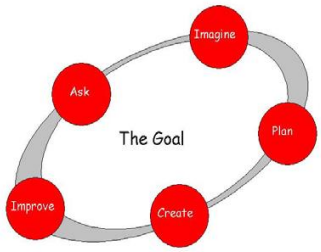
material	Total amount	Consumable	Non- consumable
Table	5	x	✓
Chairs	20	x	✓
Projector + Screen	1	x	✓
Standard A4 Paper (can be scrap)	200	✓	x
A variety of other paper/card types e.g Newspaper, tracing paper, thicker paper	50	✓	x
Art straws	100	✓	x
Tape	5 rolls	✓	x
Scissors	20	x	✓
Rulers	20	x	✓
Pencils	20	✓	x
Hoops	2 per testing area	X	✓
Fishing wire or hoop stand	5m	✓	✓

The workshop

Introduction

1. Welcome the participants and introduce them to the museum. Explain that this workshop is about designing, building and testing different types of paper aircraft.
2. Describe the structure of the session to them - an introductory presentation followed by a practical workshop.
3. Introduce the concept of the Engineering Design Process (EDP), using the questions and comments below as a guide. When asking questions allow participants to discuss their answers with each other first, before inviting selected children to share their suggestions.

The Engineering Design Process



Ask the participants 'what do engineers do?'

Can dispel some of the misconceptions that the group may have at this stage, such as assuming engineers are men or that they only work on cars.

Explain that engineers use science and technology to solve problems and that there are many different types of engineer.

Explain that engineers who work on things that fly through the air are known as AERONAUTIC ENGINEERS, and that in this workshop the participants will be working as aeronautic engineers.

In this next session it is assumed that participants are not yet familiar with the EDP. If they have already completed an Engineer Unit then this section will be more for revision than introduction.

Show participants the EDP diagram and explain that these are the basic steps that engineers follow when they are working on a problem. They do not always follow all the EDP steps in order as they often loop back to an earlier step and repeat particular stages of the process again.

The first step is the ASK step, what do they need to know before they can get started?

Ask the participants 'what do you need to know to get started with this workshop?'

One response is likely to be – what exactly is our workshop challenge/engineering problem? This allows you to introduce the specifications of their workshop challenge in more detail. Explain that that they need to use the EDP to build a variety of paper aircraft using the materials provided. They will need to test their aircraft in the test area to find out which one is best suited to flying through a hoop that is 3m away from the throwing point.

Other responses might be – 'how do we make different types of paper aircraft?' and 'how do things fly?' etc. These questions will allow you to progress to the introductory briefing for the workshop (also part of the ASK phase).

The main activity

The main activity

Notes on what to say for each slide are on the accompanying powerpoint presentation. This would also be part of the ASK phase of the EDP.

1. *Cover slide*
2. *A photograph of an Aeronautic Engineer*
3. *A picture of the EDP*

The first three slides will be used in the section of the workshop preceding this one.

4. Forces on a paper plane
5. Elevators – adjust to climb or dive
6. Rudder – twist from side to side to turn
7. Dihedral – angle the wings up to stop rolling
8. Balancing the plane nose to tail
9. Traditional Paper Plane – title slide
10. Flying Fish – title slide
11. Record Breaker – title slide
12. Hoop Flier – title slide
13. Stunt Plane –title slide

Workshop activity – creating and testing a variety of paper aircraft to meet a specific challenge
Explain to the participants that this part of the workshop will engage them in the IMAGINE, PLAN, CREATE and IMPROVE stages of the EDP.

1. **Paper aircraft construction – demonstrations and workshop**

Demonstrate to the participants how to build three of the five different designs using the materials provided. We like using the traditional, the record breaker and the hoop flier. If you have more time, you can demonstrate all 5. If you have less time, just use the traditional. Use the videos that Science Oxford has created to help you if you wish (either beforehand as part of your preparation and/or during the workshop). We recommend the aircraft construction demonstrations are best done 'live' with each participant copying you as you go.

After you have gone through the instructions for each aircraft line the participants up at the back of the room and get them to throw their planes together towards the front so that they can all see how they fly. Each time, ask the participants to observe what kind of flight it is (e.g. fast and straight, slow and straight, fast and curved etc) and to decide whether it would be a good design to work on for the challenge.

After they have built all the designs (however many you have chosen) the participants can chose whether they would prefer to work individually or in pairs or family groups for the next part of the challenge. They should then decide which of the designs is most likely to fit the specifications of their challenge. They can then test and improve that design until the aircraft travels through the hoop.To provide more opportunities to explore and adapt their designs, include a variety of different paper types and sizes (e.g newspaper, card etc) . Explain that if they want to come up with their own design then they are welcome to do so. You may find it helpful to leave the aircraft construction videos running to remind participants what to do.

Differentiation

Here are some suggestions for how the difficulty of the task can be varied for different participants:

- Set up different throwing lines that are shorter or longer than 3m
- Use multiple hoops of shorter or longer diameters as a target for the aircraft
- Encourage families who succeed with one design to try another one
- Encourage participants to develop and test their own aircraft designs
- Encourage participants to change their materials e.g swap printer paper for newspaper

Background information for facilitator

Conclusion

Conclusion

For families we usually let people leave either when they have succeeded (if they want to) or we let them stay until the allotted timeslot is finished. In our experience families who finished early often stayed till the end trying to succeed at the more difficult tasks. We awarded stickers to participants who succeeded.

For schools, bring all the students back together 5-10 minutes before the end of the workshop to share their experiences with each other.

Recap for school version

- Ask the participants if they can remember the name of engineers who work on aircraft (aeronautic engineers)
- Ask them about the forces that there are on a paper plane (if needed show them the glider forces diagram in the presentation again)

  What is the force which acts UPWARDS on a plane ? (LIFT)

  Which force slows a plane down ? (DRAG)

  Which force makes acts downwards on a plane? (GRAVITY/WEIGHT)

Engineer Design Process (EDP)

- Ask the participants if any of them got their aircraft through the hoop first time (it is possible that a few have them might but several won't have done)
- Ask them what they had to do to succeed at the task (change designs between the 5 suggested, alter the rudder, elevators or dihedral, throw it harder, throw it from higher up etc)
- Ask them if anyone had tried a totally new design

As the participants answer the questions above, ask them to say which bit of the EDP they were using. e.g. If their aircraft didn't work they might have ASKED 'Why isn't it working?' or IMAGINED a solution, or PLANNED how to make the change and then CREATED the change. The whole process is also to IMPROVE the aircraft.

If there is a particularly reliable aircraft you could test it in front of the class.

Information for the facilitator

Background information

More information on the forces involved with flight

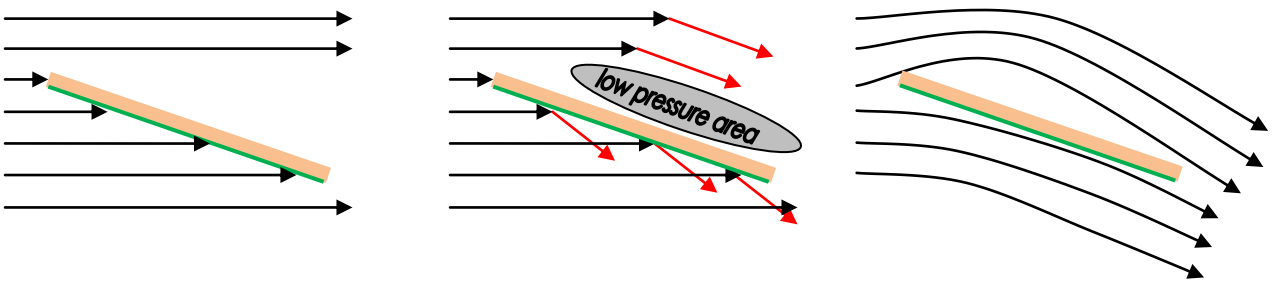
WEIGHT

WEIGHT is a term used by scientists and aeronautic engineers to refer to a FORCE which acts towards the centre of the Earth as a consequence of gravity. This is potentially confusing because generally people using the word WEIGHT actually mean MASS. Whereas MASS is a measure of how much 'stuff' there is in an object and is measured in Kilograms, WEIGHT is the FORCE acting on an object with MASS as a result of gravity. When Astronauts went to the Moon, for instance, their MASS stayed the same, as the amount of stuff in them was the same. However, their WEIGHT decreased. This is because GRAVITY is weaker on the Moon and so the astronauts would have felt a smaller force pulling them towards the Moon's surface.

LIFT

This is any force that acts in an upwards direction on the aircraft and is created by the wings and requires the aircraft to be moving forwards. The forward movement of the plane creates *relative* movement between the air and the wings this means that even on days that are not windy there is a constant stream of air passing over and under the plane wings.

There are two main factors in the way wings produce lift. One is related to the angle of the wings relative to the airflow, the ANGLE OF ATTACK, and the other is related to the AEROFOIL SHAPE of the wings. By putting the wing at an angle to the oncoming air it forces the air to split into two sets of airstreams one that travels over the top of the plane wing and one that hits the underside of the plane wing.



The long edge of the plane wing is tilted upwards into the oncoming air

Air hitting the underside of the wing increases the pressure under the wing and is deflected downwards. Air 'tries' to travel over the top of the wing undisturbed but this causes a low pressure pocket above the wing. This in turn deflects the air above the wing downwards.

The high pressure below and low pressure above the wing forces it upwards. This upwards force caused by the difference in air pressure is LIFT.

By using an AEROFOIL shaped wing it is possible to produce the same LIFT with the wing at a lower angle of attack.

THRUST

This is any force which makes the aircraft move forwards and is responsible for producing the flow of air over the wings that is required for lift. In planes this is usually created by jet engines or propellers.

Jet engines work by taking in the air surrounding the plane, compressing it, giving it lots of energy via a controlled explosion and then expelling it very fast out of the back of the engine. This sends the plane in the opposite direction. This is similar to the way a balloon moves when it is expelling air from the neck of the balloon.

The angles on the blades of propellers are such that they push backwards on the air. This is similar to a swimmer pushing backwards on the water in order to go forwards.

DRAG

This is any force which slows the plane down. There are three main causes of DRAG in planes.

- The shape of the plane
  Planes are generally long, thin, and pointed at the end a bit like a javelin. This shape disturbs the air around it the least. The less the air is disturbed, the less it slows down the plane. Plane shapes are said to be AERODYNAMIC. If aeroplanes were much blockier then the air would not be able to move past the shape as easily and the plane would slow down.

- The roughness of the surface of the plane
  Air moving past the rough surfaces of a plane causes friction similar to that between two solid surfaces. Modern planes have a smooth surface in order to reduce this force. This also helps reduce the build up of ice.

- The angle of attack of the wings
  In order to provide lift, the wings of a plane are usually angled into the direction of the airflow. However, this produces more drag than if the wings were flat. The larger the angle is, the larger the drag.

FAQ participants can ask

Usually participants want advice on making their plane fly well. Make sure you have practiced folding and flying the aircraft and understand the effects of the rudder, elevators and dihedral as well as how to adjust the plane so it is balanced nose to tail.

Problems you can encounter

The most common problems are the logistics of organising the testing areas so that participants don't get in each other's way. Having more than one testing area will make this much better. Participants should be encouraged to go back to their tables to make any alterations rather than trying to make them in the testing area.

Tips & tricks regarding the materials

Preparation

Long term:

- Learn how to deliver the introductory briefing
- Watch the videos on how to make the paper aircraft and practice making and flying them

Short term:

- Set up an area for the science show where you can show Powerpoint presentations and perform demonstrations/show videos of aircraft construction
- Set up tables and chairs for the participants that allow them to see your introductory briefing and aircraft construction demonstrations/videos
- Set up one or more testing areas for throwing the paper aircraft with a hoop suspended from the ceiling at one end
- Put a tray of building materials on each table for the participants to use to make the aircraft

Test Areas

The easiest way to mark out a test area will be to use masking tape or similar. The test area needs to be wide enough to fit a hula-hoop in and at least 3m long with the hula hoop at one end. We find it better to have two hoops, one at 3m and one at 5m to add more challenge (it is probably better if you have at least 50cm beyond the hoop so that the planes can actually fly through it). These hula-hoops could either be suspended from the ceiling using fishing line or alternatively clamped to a table/pole. Having more than one test area is advantageous as it reduces queuing and also allows you to set up lower hoops for shorter children, when working with families. Ideally the test areas should have someone managing them so it is probably sensible to have them close to each other where possible.