Aberfoyle Park High School

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Space Potatoes

This experiment aims to explore the rate of food spoilage in zero gravity conditions compared to those on earth. The results of both experiments will be recorded with cameras placed above them. A potato will be used in this experiment because of their abundance and usability. Also, they will be used because of their potential to be used in future space missions and possible mars colonisation.

After a year in low earth orbit conditions, the footage recorded will be compared with the footage recorded on earth, to see if zero gravity had any effect on the spoilage of a potato. If space decelerates the rate of spoilage, it is likely that potato will be the first choice for space missions of the future.

This experiment completely follows each safety guideline and experiment requirements. The container that the potato will be stored in is completely sealed, to prevent possible circulation of unwanted materials throughout the International Space Station. Also, this experiment is within the suggested dimensions and is below the size limitations.

1.0 Links to STEM

This experiment has multiple links to STEM through the engineering design process, in addition to the science, maths and technology curriculum outlined by the Australian Curriculum and SACE.

Science:

Stage 1 biology covers the topic of cells and microorganisms which focuses on how microbes can both be beneficial and potentially harmful to human health and society. This topic explores food spoilage and strategies in which to handle food safely to prevent microbe growth and wasting food resources in addition to negatively impacting on our health. Storing food in space can be explored as a section of this topic; how would microbes survive in the space environment when faced with a multitude of different environmental factors?

Stage 1 and stage 2 agriculture courses look at the principles of agriculture and enterprise management. This focuses on how to manage crops and produce effectively with developing technology and how to cope and find solutions to ethical and safety issues related to crop production and spoilage. How microbes behave and survive in space could provide a food storage option in the future to help minimise waste.

Technology and Engineering:

The design process (as outlined below) is essential to stage 1 and 2 design and technology subjects. Designing in technology is purposeful, systematic, creative, and cyclic, with many possible solutions. A four-part designing model — investigating, planning, producing, and evaluating — is used in this subject. The process should begin with the identification of a need, problem, or challenge, followed by an initial investigation, and then the writing of an open design brief that may specify parameters or requirements. The problem or need investigated in this project was how to minimise food wastage and economic loss through the utilisation of the space environment. How the design process was used is outlined in detail below.

Design and technology subjects also involve the use of materials such as symbols, images, sound, or other data to design and make products that communicate information. This was seen in this experiment through the use of computer aided design to communicate the initial design for the experiment prototype. These subjects also employ the use of a diverse range of manufacturing technologies such as tools, machines and equipment to design and make products with materials such as metals, plastics and wood. Tools and machinery were used to shape acrylic plastics and timber into the initial prototype created for this experiment.

Mathematics:

General mathematics skills and capabilities were employed throughout the design and manufacturing process. Throughout the middle school Australian Curriculum, the topics of number, geometry and measurement are continually covered and built upon, with those concepts being used repeatedly in the designing and planning process.

These topics are also built upon in senior mathematics, particularly in Essential and General mathematics. Furthermore, when modelling the growth of any bacterial cultures that develop within the experimental time frame, exponential functions would be used to best model the increase in cultures. This directly links to stage 1 mathematical methods and year 10 and 10A.

2.0 Practicality and Usefulness

Food spoilage is a critical issue that has led to hundreds of billions of dollars being thrown away. Every year Australia on average wastes 4 million tonnes of food and 8 billion dollars on spoiled food. Through this experiment, it can be determined whether storing agricultural produce in space is a viable solution to this problem. The results will also be beneficial for future manned space flight missions and possible planetary colonisation on planets such as Mars, as food will impact on the mass of the spacecraft, and in turn, it's overall cost.

This experiment will allow data to be collected and analysed around how and when food spoils in the hostile environment of space. This spoilage rate (if any) will also allow a comparison between how effectively microbes are able to grow in the different conditions that space presents, such as extreme temperatures and lack of oxygen.

If the food does not spoil during the experiment it may show the potential to store food in space which could minimise the strain on Earth's resources. Based on the most recent study undertaken by the UN, there are currently 7.3 billion people living on Earth, and this number is expected to rise to 9.7 billion by the year 2050. This obviously means that the demand for resources are going to increase as well, with the demand expected to increase somewhere between 59% to 98% by the time the world reaches 10 billion people. This means that space is going to become an issue as the amount of food needed increases. This is already resulting in increased deforestation and habitat loss in order to clear land for crop production. If food can be stored in space without the same impacts of spoilage, it may reduce the demand on farming and crop production which is already under heavy strain.

Looking ahead to the future, the ability to successfully store food in space without spoiling or rotting will also be of benefit for any long term space exploration missions to other areas of the solar system, and potential colonisation of other planets.

3.0 Engineering Process

The engineering process detailed in figure 1 is currently being undertaken to ensure the design of a suitable experiment which meets all requirements. The process began with identifying the need to reduce the strain on the world's agricultural industry by reducing waste through food spoilage (and therefore also minimise economic loss). The engineering and design process is currently ongoing and the prototype is still being tested under various conditions and refined.

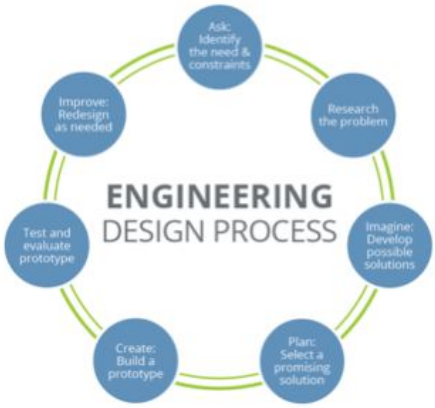

Figure 1: Engineering Design Process

Ask: Identify the needs & constraints

Needs:

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Constraints

The experiment design is required to withstand:

- G forces up to 7.5g
- temperatures between -20 and +50 degrees Celsius
- impact forces equivalent to dropping the experiment from a height of 20cm onto carpet
- galactic cosmic rays (multiple forms of radiation) broadly equivalent to the expected radiation dose from 15000 chest X rays.
- must weigh less than 300g and fit within a volume roughly equal to a 1 litre milk carton

Imagine, develop possible solutions

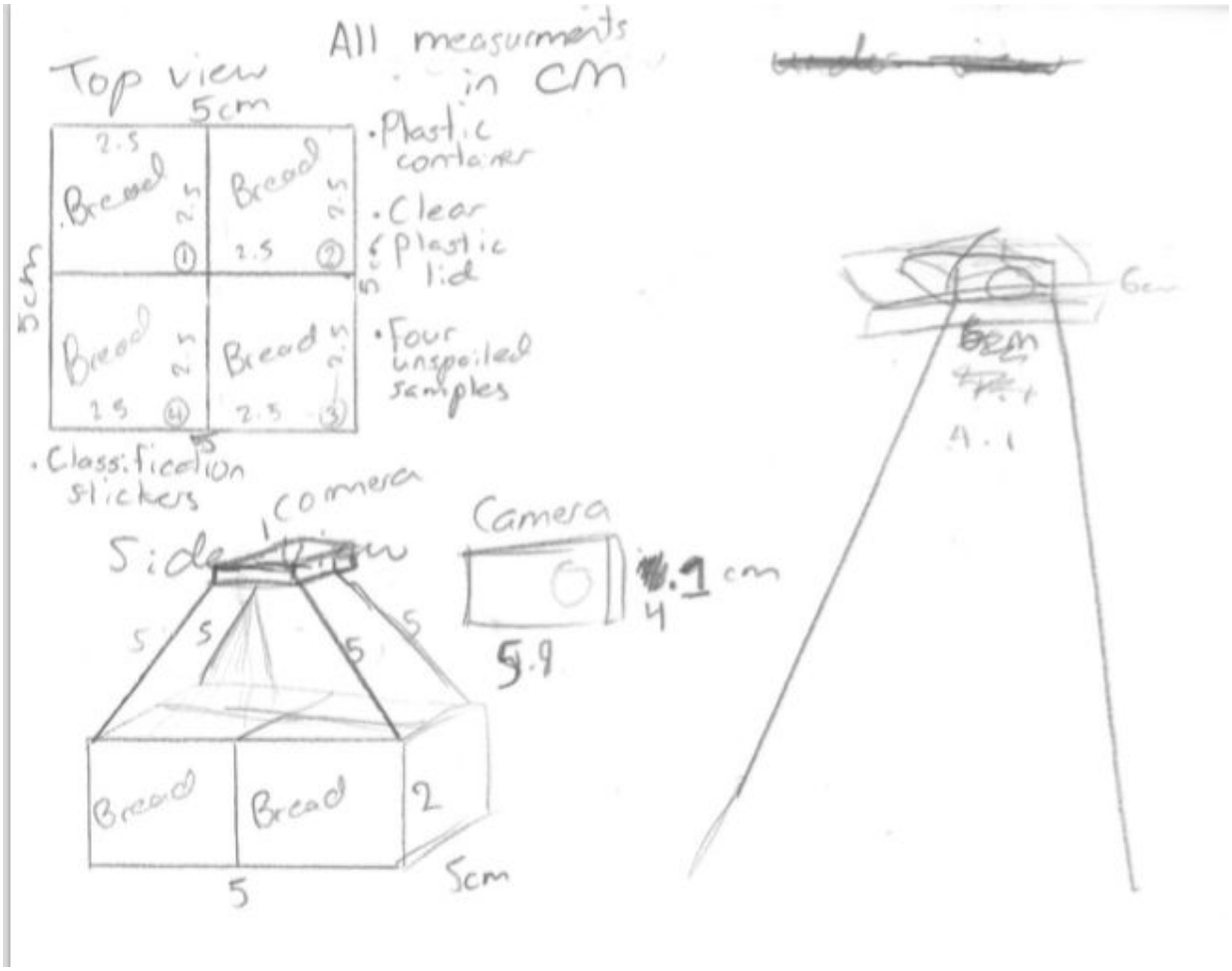
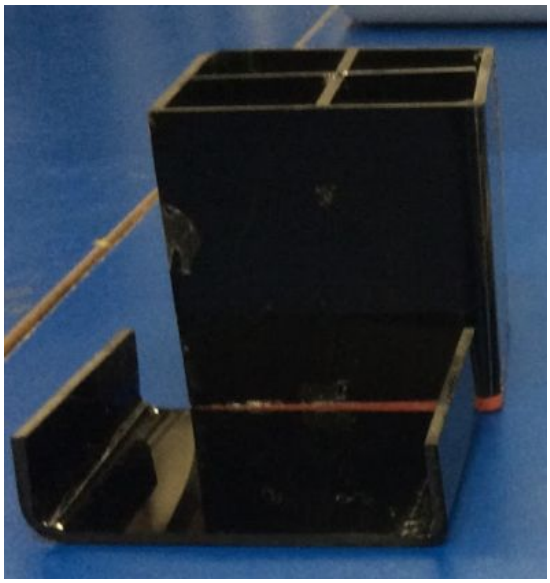


Figure 2: Initial ideas

- Four components to test four different experimental conditions
- Plastic as a material
- Camera on top to view anything that grows
- Bread will be the food used
- Metal will hold the GoPro up

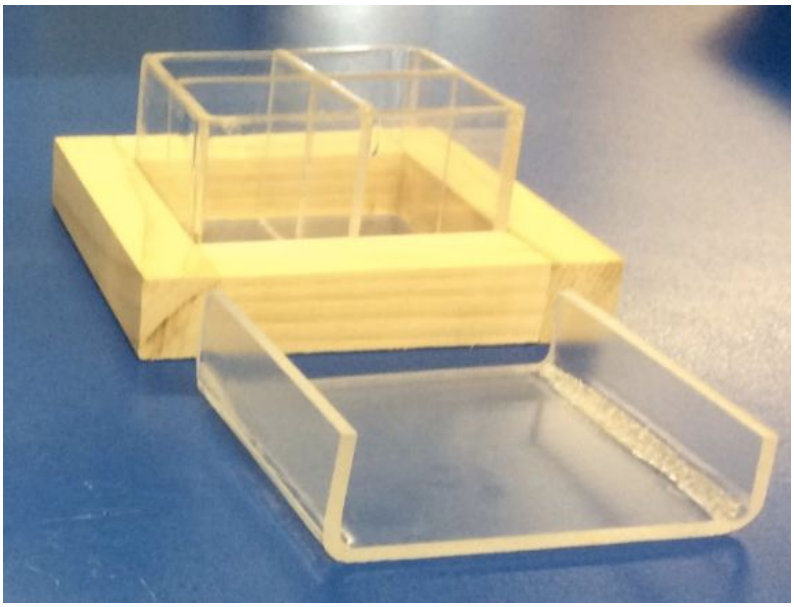


- Use of acrylic
- Red acrylic for bottom of design
- Black acrylic for lid and body

Initial Observations

- Higher than the proposed design
- Colour choice of black will make it difficult to view the potato.
- Need to consider alternate arrangements.
- Bread changed to potato based on feedback

Figure 3: First Prototype



- Clear acrylic allows the organic material to be clearly seen
- Timber frame has made the object too large to meet dimension requirements, will need to investigate alternative.
- Not sure about the seal of the lid to the body

Figure 4: Second Prototype

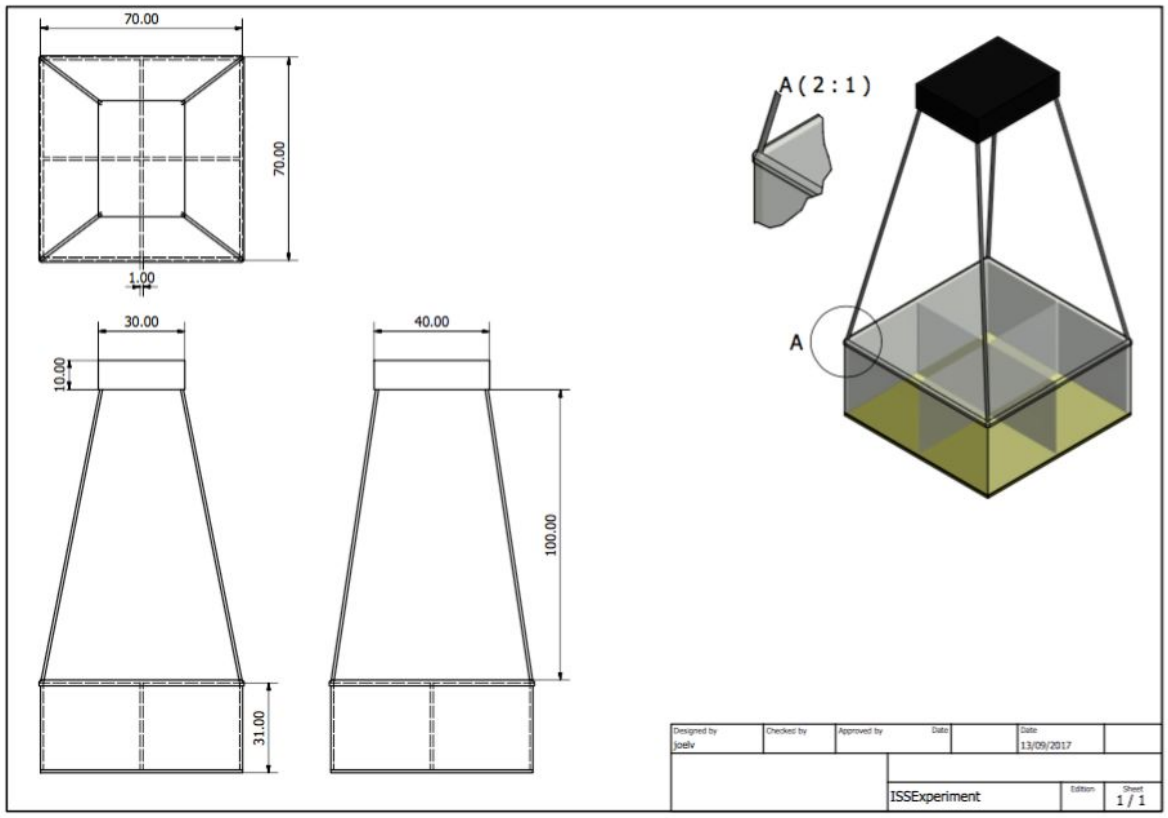
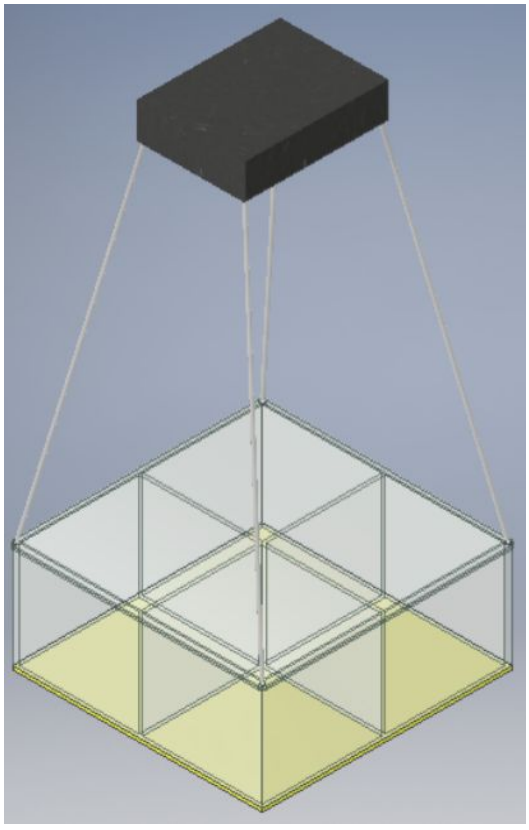


Figure 5: Diagram of final prototyped developed using CAD.



Final Prototype to include

- Clear acrylic for body and lid
- Thin metal rods to hold up a box for the camera

Test & Evaluate the prototype

1. *Drop Test*

A drop test was conducted from approx. 20 cm above ground. The prototype sustained no damage and was therefore considered a reasonable material to use for construction of the final product.

2. Ice Ice Baby

The prototype was placed in a freezer at -18 degrees celsius for 24 hours. The acrylic used maintained it's integrity and no damage was noted.

3. Hot Potato, Hot Potato

The prototype was placed in an incubator at 30 degrees celsius and no damage to integrity was observed. The prototype was placed in an oven at 50 degrees celsius and again no damage to integrity was observed.

4. Silent but deadly

The organic material (potato) will need to be sealed in the prototype and any potential gas production will need to be measured to make sure the it complies with safety requirements of the ISS.

Links to Industry

Multiple links have been investigated in the food research industries and universities, however none were able to provide support or advice during the development process.