BOWLAND
MATHS
Case Studies

ASTROZOO – LESSON GUIDE

Introduction

The AstroZoo case study has four bio-domes, each of which contains four missions. Pupils are divided into groups of three or four and select one of the four bio-domes to explore in order to solve, using mathematics, some critical environmental problems the zoo is facing.

Three of the missions they encounter in their chosen bio-dome are completed with the support of the computer software, while the fourth is a paper-based task that could be completed as a classroom or homework task.

Each computer-based mission can be introduced to the whole-class using the teacher's computer connected to a data projector. Once pupils have understood the nature of the mission, they can work independently or in groups to prepare a 'Mission Report' for the AstroZoo managers. This report should include their solutions to the problems and, most importantly, their accompanying calculations and mathematical reasoning.

The mathematical content

This case study provides opportunities for pupils to work on Key Concepts and Key Processes in the KS3 National Curriculum Programmes of Study. Pupils are expected to consider how mathematics is represented by identifying the mathematical aspects of the situation and selecting the mathematical information, methods and tools to use. They use the software to explore the effects of varying values and look for invariance, taking account of feedback to support them to work logically towards results and solutions. In reporting their outcomes to the zoo's managers, they consider the best way to present their findings.

The mathematical content that pupils are likely to use will be determined by their existing knowledge; this might include the following:

Number and algebra:

- Rules of arithmetic applied to calculations and manipulations with both rational and decimal numbers
- Applications of ratio and proportion, including calculations of percentages
- Accuracy and rounding
- Substitution into algebraic formulae - for example, to calculate areas
- Linear relationships

Geometry and measures:

- Units, compound measures and conversions
- Perimeters, areas, surface areas and volumes

Organisation and pedagogy

The AstroZoo case study supports 2-3 one hour lessons of classroom activity with the option of related homework activities.

A mixture of whole class and small group work is involved. An interactive whiteboard or computer and data projector are essential for demonstration purposes. To use the materials, a PC or Mac with a soundcard/speakers and DVD drive is required.

In keeping with the ethos of the Bowland approach, the teacher's role is to set pupils realistic targets, challenge them to think and reason for themselves and manage discussions and plenary reporting sessions. Techniques should only be demonstrated as a last resort. Throughout, the goal is to develop pupils' ability to work and think independently.

Suggested sequence of events

Note: Since pupils working with the software can generate solutions by trial and error, it is important to retain control of the software, using it to test pupils' hypotheses/calculations or check the final conclusions they have worked out for each mission.

1. When the software loads, an introductory animation explaining the AstroZoo scenario will play automatically. Whilst the animation is playing, encourage pupils to record any important facts that they think might be useful later in the task.

(Note that sound output and speakers [or headphones] are strictly required only for this animation – although there is background music/sound effects for the tasks themselves.)

2. Following this, click on each of the four bio-dome enclosures of the AstroZoo to reveal the space creatures that it contains, some details about their requirements and the ecology of the dome.

3. Once they have seen the creatures in each dome, divide the pupils into groups.

4. Each group should choose which **one** of the creatures/domes they are going to try to rescue (Any group of pupils could repeat the exercise with a second dome. However, although it is possible, it is not a good idea for them to switch between domes for the different missions.)

By viewing each of the bio-domes, pupils can discover the distinctive characteristics of the type of creature that lives in it – its appearance, weekly food needs, the temperature range it can tolerate and other important facts.

The important facts about each bio-dome and the creatures within are provided in the Creature/Bio-dome Profile sheets. Pupils will need to draw from these facts and figures in order to complete each mission. The information is always available on screen or alternatively copies of the Creature/Bio-dome Profile can be printed for the pupils to refer to during the missions. You might want to print them on card or as laminates so that they can be re-used in future lessons.

Pupils can keep track of their progress through the three missions in each dome by rolling your cursor over each dome within the home screen: the blue status indicators change to green as each mission is completed. This information is reset each time the software is opened.

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Mission 1: Crisis!

a) Background

Past overcrowding of creatures within each bio-dome is putting a strain on the air supply. Three key factors have emerged:

- Oxygen resources have been overused and each bio-dome is down to its last oxygen tank.
- Air filters have broken down, meaning that the CO_2 the creatures are producing is poisoning the air and leaving all species looking tired and lethargic.
- To ease the strain on the resources, it looks as though the managers may need to reduce the number of creatures in the bio-domes and return the others to their home environment.

The task for the pupils involves using the AstroZoo software to gather data about the O_2 and CO_2 levels in the atmosphere for different sizes of creature populations. They then need to make their own calculations for the maximum number of creatures that can survive the 100 days in their bio-dome, given the two constraints.

Here is the on-screen information the pupils receive about Mission 1:

MISSION 1: THE ZOO IS RUNNING OUT OF OXYGEN!
Your bio-dome is down to its last tank of oxygen and CO_2 filters have broken down through overuse. Emergency supplies won't arrive for another 100 days… but can the current number of creatures survive until then?

Calculate what will happen to the O_2 and CO_2 levels over the next 100 days with the current population level. Then, try out different population numbers and see their effect on the O_2 and CO_2 levels.

*Your mission? To calculate the **highest number** of creatures you can keep in the bio-dome in order for them to all survive. You'll need to be able to explain your reasons in your report to the managers.*

b) Practical aims of this task

In this task pupils observe what happens to the O_2 and CO_2 levels with a single run of the software by the teacher on the whiteboard – using the current number of creatures (for each of the bio-domes) as the default value. The software will then display the O_2 consumed and the CO_2 produced after 100 days for the numbers of that particular creature in its bio-dome.

Pupils then use this information, alongside the atmospheric constraints, to work out the **maximum population** for that species. They should be able to explain the logic behind their conclusion in their Mission Report. To avoid pupils trying to find the solution by repetitive trial and improvement, they should NOT have access to the software until they have completed their calculations – with their reasoning; the software can then be used to check their answer.

This is the most straightforward of the four missions within each dome and is therefore suitable for lower attaining pupils. More able pupils could be asked to record the information using tabular and/or graphical forms and be challenged to describe the relationships algebraically.

c) Suggested sequence of events

1. The simulation screen opens with the current starting population size for each bio-dome. It is strongly recommended that this initial value is not changed as it is possible to select the optimal/workable answers accidentally and then the purpose for the mission within the selected dome will have been lost. Run the calculation for each bio-dome and ask the pupils to discuss what they noticed was happening on the screen for their bio-dome after it has finished running.

2. Give the pupils a copy of the Creature/Bio-dome Profile sheet and the Mission Planning sheet. Initially, encourage them to record the problem in their own words and then to identify the information on the Creature/Bio-dome Profile Sheet that might be most useful to help them work out the optimum population size so that the creatures will be alive and healthy in 100 days time. If pupils are working in groups of four, each pair could focus on either the CO_2 or the O_2 levels.

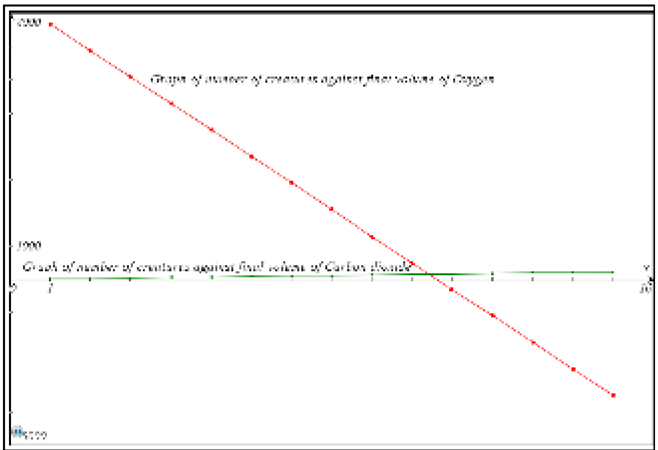
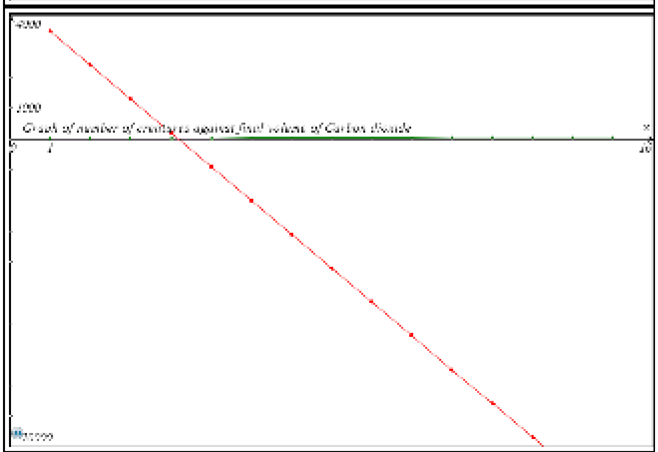
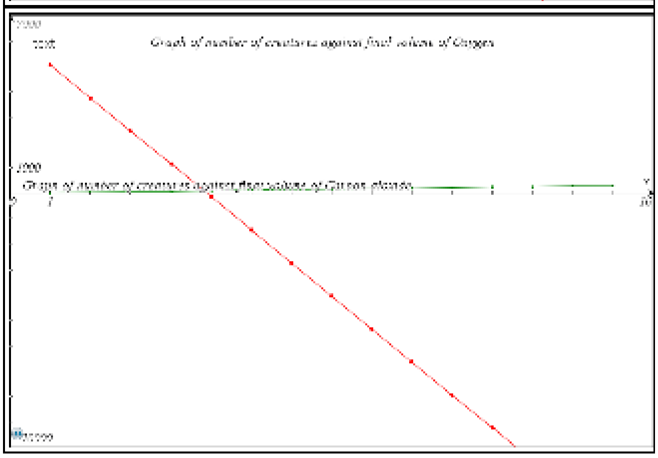
For reference, the optimum populations for each Bio-dome are shown below.

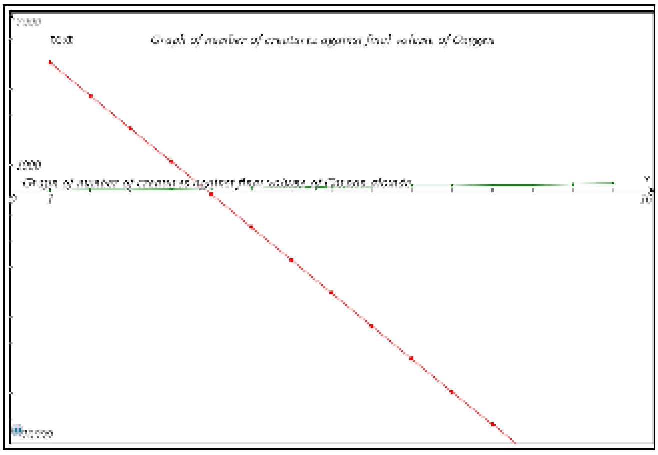
Bio-dome	**Creature**	**Optimum population size**
1	Neon Plasmoid	5
2	Galactic Stegotron	4
3	Solar Bi-ornithos	3
4	Thallein Scuttlebug	5

<u>Possible questions to prompt pupils' thinking</u>

- What quantity of CO_2 will be toxic for your particular bio-dome?
- How much CO_2 does each creature produce each day?
- How much oxygen does one of your creatures need each day?
- What is the maximum number of creatures that you can keep in the enclosure without reaching the toxic levels?

3. Once each pair of pupils has obtained their solution, ask them to come back together and present the findings and rationale to each other. Looking at both sets of data – that for the O_2 and that for the CO_2 – ask them to make a conclusion about the maximum number of creatures that the enclosure can sustain for the next 100 days and explain their thinking. Be aware that for Domes 1 and 3, the limiting factor is the creatures' CO_2 tolerance whereas for Dome 2 and 4, it is the amount of O_2 that is initially in the Dome. More able pupils could be asked to explore the underlying mathematical model, encouraged to show the model graphically and to express it in words and using algebra.

	Relationship between number of creatures (x) and final volume of O_2 in the Dome after y_1 days	Relationship between the number of creatures in the Dome (x) and the volume of CO_2 in the Dome after y_2 days	The graphical representation of the two relationships, which pupils could use to justify the solution to the problem.
Dome 1	$y_1 = 8500 - 800x$	$y_2 = 15x$	
Dome 2	$y_1 = 4600 - 1100x$	$y_2 = 5x$	
Dome 3	$y_1 = 6350 - 1300x$	$y_2 = 20x$	

Dome 4	$y_1 = 16750 - 3200x$	$y_2 = 18x$	

4. Support the class to compare their findings and methodologies and invite them to test their conjectures using the AstroZoo software.

A plenary for the whole class will be simpler if all groups have used the same bio-dome; although this is not strictly necessary as the principles are the same for each bio-dome so a plenary on principles would still be helpful to explore the common challenges shared by the mission types.

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Mission 2: A new day!

a) Background

Success! Not only have the creatures been kept alive, but the more appropriate population sizes mean that the creatures are now much healthier too. The AstroZoo managers want to prevent such an emergency happening again and have asked the pupils to find a more a sustainable solution for the zoo's oxygen and food supplies.

Here is the on-screen (and printable) information the pupils receive about the mission:

MISSION 2: A NEW DAY!
The creatures are now much healthier and the AstroZoo managers are challenging you to find a more sustainable, longer term solution for the creatures' oxygen and food supplies.

*They are thinking about growing OxyTurf and FoodGrass on the plantable surfaces in each dome. Click on the buttons on the left for the information about **OxyTurf** and **FoodGrass**.*

Your mission? To work out and report back to the AstroZoo managers on out how best to divide the land in your bio-dome between OxyTurf and FoodGrass to meet the creatures' needs every day.

The managers have already suggested four possible divisions of the plantable land for the different proportions of OxyTurf and Foodgrass that could be planted in the Dome. Choose an idea and Run the simulation to see how much O_2 remains and how much food energy is left after 24 hours.
Can you decide which of the ratios, A, B, C and D is better and why?
Be prepared to report back.

INFORMATION SHEETS
OXYTURF

- *OxyTurf is a plant with a difference!*
- *Each square metre of OxyTurf produces a fixed amount of O_2 (in m^3) every 24 hours*
- *OxyTurf grows well anywhere except rocky ground.*
- *O_2 is valuable and can be used in other areas of the AstroZoo.*

FOODGRASS

- *Created by Earth's smartest scientists!*
- *FoodGrass tastes delicious but will not grow on rocky land*
- *Each square metre planted produces a fixed amount of food energy (in kJ) every day*
- *FoodGrass re-grows at the end of each day*

b) Practical aims of this task

The task comprises two different stages in which pupils first analyse the proposals of the zoo's managers and then make proposals of their own. The first stage involves using the

AstroZoo software to encourage pupils to think about how different ratios of OxyTurf and FoodGrass (expressed as ‘Managers’ Ideas’) will result in different outcomes and that some of these outcomes will be better than others.

The pupils begin by testing the four different pre-set ratios of OxyTurf to Food Grass (A, B, C and D) by using the AstroZoo software and selecting ‘Test’. For the selected ratio, they will see the O_2 (in m^3) and food energy (in kJ) remaining after 24 hours in that particular bio-dome.

The pupils then use this information to discuss which of the four ratios gives the better solution and why. Following this, the pupils should be told what were the four ratios that were used and challenged to match these values to the four ‘Managers’ Ideas’ A, B, C and D, working out which corresponds to which.

Once their analysis of the ‘Managers’ Ideas’ has been completed, the pupils use what they have learned to identify their own preferred division of the land and to see if they can improve the managers’ attempts. They do this by selecting the ‘My Ideas’ tab and entering numerical values for the areas of OxyTurf and FoodGrass. that they would like to simulate.

It is possible to cover the basic needs of the creatures while still generating a surplus of either O_2 or kJ. When pupils submit their own ideas into the interface they will receive feedback prompts saying that zoo management involves more than simply keeping creatures alive – they also need to keep them happy. As such they are asked to reflect upon what else they know about the creatures in their bio-dome and whether they might be happier with a surplus of O_2 or a surplus of food energy.

Although the pupils will all have to achieve the goal of keeping their creatures alive, there is no definitive ‘ideal’ answer for keeping the creatures happy. Rather, pupils should be encouraged to formulate (and defend) their own hypotheses, based on the information available elsewhere in the interface and in the fact-sheets.

c) Suggested sequence of events

1. The simulation screen opens with a starting ratio of OxyTurf to FoodGrass. There are four different pre-set ratios which can be selected. Select a ratio, press ‘Test’ and ask the pupils to discuss in pairs what they notice happening on the screen.

2. Ask the pupils to note down on the Mission Planning Sheet any aspects of the problem that they might need to know to work out how best to divide the land so that the creatures have enough oxygen and food.

3. Give out the Creature/Bio-dome Profile Sheet so that each group of four has a bio-dome to focus on. Ask the pupils to review their Mission 2 Information Sheet and tick-off the information that they know.

4. There are four different ratios of OxyTurf to Food Grass for the pupils to try. During the simulations, the pupils will see the O_2 and food energy that remain after 24 hours.

For all of the domes, the Mystery Ratios are:

A	B	C	D
OxyTurf:FoodGrass	OxyTurf:FoodGrass	OxyTurf:FoodGrass	OxyTurf:FoodGrass
1:3	1:1	2:1	1:2

And the interpretations that can be made from the results are:

Dome 1 *Neon Plasmoid*	Not enough O_2 produced to keep the creatures alive and a surplus of food energy produced.	A surplus of both O_2 and food energy is produced.	A surplus of O_2 is produced but not enough food energy to keep the creatures alive.	Enough O_2 is produced to keep the creatures alive and a surplus of food energy produced.
Dome 2 *Galactic Stegatron*	Not enough O_2 produced to keep the creatures alive and a surplus of food energy produced.	A surplus of both O_2 and food energy is produced.	A surplus of O_2 is produced but not enough food energy to keep the creatures alive.	Enough O_2 is produced to keep the creatures alive and a surplus of food energy is produced.
Dome 3 *Solar Bi-Ornithos*	A surplus of both O_2 and food energy is produced.	A good surplus of O_2 is produced but not enough food energy to keep the creatures alive.	A good surplus of O_2 is produced but not enough food energy to keep the creatures alive.	A surplus of both O_2 and food energy is produced.
Dome 4 *Thallein Scuttlebug*	Not enough O_2 is produced to keep the creatures alive, but a surplus of food energy is produced.	A surplus of both O_2 and food energy is produced.	A good surplus of O_2 is produced but not enough food energy to keep the creatures alive.	Not enough O_2 produced to keep the creatures alive and a surplus of food energy is produced.

<u>Possible questions to prompt pupils' thinking</u>

- Which of the ratios results in surplus food energy?
- Which of the ratios results in surplus O_2?
- Is one ratio better than another?
- Do you think any of the ratios is the 'ideal' split?
- Can you think of a better way to divide the land? Might it be better for your creatures to have a surplus of O_2 or a surplus of food energy?

5. After testing the ratios, the pupils can request more information about the 'Managers' Ideas' and use this new information alongside their existing data from the simulation and the Dome data sheets to calculate the amount of energy (in kJ) each m^2 of FoodTurf produces and the amount of O_2 (in m^3) each m^2 of OxyTurf produces over a 24 hour period.

<u>Possible questions to prompt pupils' thinking</u>

- What is the missing information that you need to find?
- What data do you know?
- How can you use this data to find out the missing information about the FoodGrass and Oxyturf?

FoodGrass	Each m^2 produces 125 kJ of food energy over a 24 hour period
OxyTurf	Each m^2 produces 0.3 m^3 of O_2 over a 24 hour period

6. Using this information, the final part of the challenge is for pupils to work out a better division of FoodGrass to OxyTurf by calculating the areas of each that should be planted.

- How much food energy (in kJ) do your creatures need in one day?
- How many m^2 of FoodGrass would produce this?
- How much plantable land would you have left?

7. When the pupils have obtained their solutions, ask them to come together in their groups and present their findings and rationales to each other. Using the software, pupils can enter their own solutions using the ‘My ideas’ section to test their simulations.

If pupils struggle to understand how to make their creatures happier, they can be directed to review the fact-sheets which describe how the creatures behave in their native habitat. This brings out an important point both about zoo management and about the whole idea of sustainability – covering basic needs is not in itself sufficient, any zoo must look to give its inhabitants a decent quality of life. Zoos typically put a great deal of effort into allowing animals to behave as they would do in their native environment as this is a central factor for their wellbeing. The pupils will need to consider how their creatures prefer to behave and whether they might need extra O_2 or extra food energy to be able to do that.

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Mission 3: Heatwave!

a) Background

With success comes a new set of problems. Now, the zoo's power needs are spiralling out of control and as a result, it is starting to overheat!

Vital StellarShields, which protect the zoo from stellar radiation, have been removed to make way for PowerPanels which use the stellar radiation to top up the zoo's power needs. The zoo will continue to become far too hot if stellar radiation keeps getting through into the bio-domes – unless something is done!

MISSION 3: HEATWAVE!
Oh no. The zoo's power is out of control and it's starting to overheat!

Over time, StellarShields which protect the zoo enclosures from stellar radiation from the nearby star have been removed to make way for PowerPanels which use stellar radiation to top up the zoo's power needs.
Unfortunately, too many StellarShields have been removed, meaning the zoo will get far too hot if nothing is done!

Your mission? To calculate how to cover the outside of your bio-dome with PowerPanels and StellarShields so that there is enough power for the next 12 months – while also creating a comfortable temperature for the creatures.

Test out the temperatures reached and amount of power produced for the different ratios of PowerPanels to StellarShields. Use this information to work out the best division of the Dome surface area to try to find a sustainable environment for the creatures.

If you can generate a power surplus you can use it to make the AstroZoo brighter and more visible to passing spaceships, so attracting more visitors to come and learn about the endangered species for which you are caring.

INFORMATION SHEET

POWERPANELS

- *These are essential for generating power in space!*
- *Each 1m^2 of PowerPanels produces a fixed amount of power in kilowatts.*
- *PowerPanels are not 100% efficient - some radiation will reach the Dome and will raise the temperature at a rate of 0.1℃ per PowerPanel per year.*
- *You cannot place PowerPanels in front of the StellarShields*

STELLARSHIELDS

- *These shields protect the zoo from the stellar radiation.*
- *StellarShields are 100% effective at reflecting stellar radiation*
- *Each StellarShield reduces the temperature in the Dome by a fixed amount.*

For this mission, pupils need to use the AstroZoo software to test out different ratios in order to find the ideal division of StellarShields and PowerPanels to cover their selected bio-domes over the next **12 months** – keeping the creatures at a comfortable temperature while generating the greatest amount of surplus power. As in Mission 2, there is a second stage to the activity in which the pupils are asked to build on what they know to develop their own definition of success.

b) Practical aims of this task

In this mission, the pupils use the AstroZoo software to test out different ratios of StellarShields to PowerPanels. Rather than starting by analysing ratios suggested by the Managers, in this Mission they begin by proposing different ratios themselves. When they run the calculation for a chosen ratio they will see the kilowatts generated and the temperature reached at the end of 12 months for a particular bio-dome. Pupils can then use this alongside information about the Dome's surface area to calculate the output values of the StellarShields and PowerPanels. This would include the rate of power generation by the PowerPanels and the rate of temperature reduction of the Stellar Shields, taking account of the extra complication of the warming effect of the PowerPanels.

Having found out this missing information, pupils should be challenged to find a division of PowerPanels and StellarShields that provides a suitable temperature for the creatures living in that particular bio-dome, but to also try to find the **optimal division of shields and panels** that, after 12 months, produces the largest surplus of kilowatts with an acceptable temperature range. The pupils should then explain the logic behind their ideas in their Report to the zoo managers.

As an extension activity, carried out away from the software, pupils could investigate how they should continue to change the ratio of the different panels over the next ten years to respond to the temperature variations. For example, in the first year, the ratio will need to cause the temperature to drop. But if the distribution of StellarShields and PowerPanels is left at that ratio, the temperature will **continue to drop** in every subsequent year, eventually pushing the creatures below their tolerance levels again, by making them too cold. The pupils should consider how they will need to continue to vary their set-up of StellarShields and PowerPanels so as to balance keeping the creatures comfortable with generating a power surplus to attract more visitors – and so publicise the plight of the creatures.

Questions that might come out of this activity include:

- Is it acceptable to keep the creatures right at the limit of their tolerance levels (at which they would certainly be uncomfortable) in order to generate more power to publicise their plight for the greater good?
- Might it be better to have 'rest' periods where little energy is used to draw in visitors, allowing the temperature to readjust to optimum levels?
- Would visitors be happy to see creatures that are living right at the limits of their temperature tolerance?

Additionally, more able pupils can be given a number of other scenarios to consider, such as:

- Three months into the year, a sudden stellar flare increases the levels of radiation by 20%; now what should be done?
- Wear and tear reduces the effectiveness of the PowerPanels as they run-down so that they are only 50% efficient at the end of 12 months; what effect does this have on the arrangeemtns?

In each case, the pupils will need to make assumptions as to how these scenarios affect their mathematical model and adjust it accordingly.

c) Suggested sequence of events

The software opens with a screen where pupils can select a ratio.

Select a ratio, press ‘Test’ and ask pupils to discuss in pairs what they notice happening on the screen. Ask pupils to note down on the Mission Planning Sheet all the aspects of the problem that they might need to know to work out the best division of shields and panels to reach a suitable temperature for that particular creature.

Remind pupils that the aim is to create a surplus of power (kilowatts) that can be used to attract more space tourists , but with a suitable temperature for the creatures over 12 months.

Give out the Creature/Bio-dome Profile Sheet so that each group of four has a bio-dome to focus on. Ask the pupils to review their Mission Planning Sheets and tick-off the information that they know.

Pupils can enter their own sets of ratios into the interface. During the simulations, pupils will see the kilowatts generated and the temperature reached. From this information, combined with the information on the bio-dome cards and the knowledge gained from Mission 1 and Mission 2, they will be able to calculate kilowatts generated and therefore what power surplus will be left after 12 months. Consequently, pupils can then work towards finding the optimum division between shields and panels that will leave the largest power surplus at the same time as creating a suitable temperature for the creature.

Possible questions to prompt pupils’ thinking

- How is the radiation affecting the temperature in the bio-dome? How do you know?
- Is one ratio better than another?
- Do you think there is an ‘ideal’ ratio?
- How could you divide the surface of the bio-dome to create the biggest possible power surplus – while still keeping the temperature right for the creatures?

When pupils have obtained their solution, ask them to come back in their groups and present their findings and rationales to each other. Looking at both sets of data, ask them to make a conclusion about the best division of the bio-dome surface over 12 months.

Support the class to compare their findings and methodologies.

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Bonus mission: Predators!

a) Background

The hard work has paid off and the zoo is attracting visitors again! Keen to learn from past mistakes, the managers have agreed not to cram too many creatures into the bio-domes. Instead, to maintain the zoo's success, they are constructing a new bio-dome… with TWO new species**:** Devouros and Space Drones.

> ***Devouros***
> *A large predator from the Milky Way, the Devouros feeds on Space Drones!*
> - *Each Devouros eats 150 Space Drones per year*
> - *A Devouros does not need a mate to reproduce. It produces a clone of itself at the end of the Space Year if there are at least 150 Space Drones per Devouros*
> - *If at the end of a Space Year, there are less than 150 Space Drones per Devouros in total, sufficient Devouros will lay down their lives to bring the number back into balance with the food supply.*
>
> ***Space Drones***
> *Mindless creatures that multiply rapidly, Space Drones are a galactic pest – fortunately they are also the food of the Devouros.*
> - *Space Drones feed on microscopic organisms in the air, meaning there is no need to buy food for them*
> - *The Space Drone population increases rapidly - at the start of the Space Year, during their breeding season, the Space Drone population doubles.*

The first Devouros has been bought and introduced into the new bio-dome half way through the Space Year. The zoo doesn't have a lot of money left over, so needs to buy the lowest number of Space Drones that it needs.

For this mission, pupils need to work out the **lowest number** of Space Drones that will enable the Devouros to survive.

To do this, pupils need to create a population plan for the next ten years. The software is not used for working out predictions – this should be done on paper or using a spreadsheet package such as Excel or TI-Nspire.

b) Aims of this task

In this mission, the pupils need to model the population for the next ten years using the information they have been given on the behaviour of the Devouros and the Space Drones.

The aim is to work out the lowest number of Space Drones that will enable the Devouros species to survive over the next ten years.

The pupils should then explain the logic behind their ideas in their Report to the zoo managers.

<u>Possible questions to prompt pupils' thinking</u>

- A Devouros will eat 150 Space Drones over the course of a year
- At the end of the Space Year, each Devouros will produce a clone but only if at least 150 Space Drones per Devouros remain
- At the end of the Space Year, if there are less than 150 Space Drones per Devouros, the excess Devouros will lay down their lives
- At the start of each Space Year, the Space Drone population doubles

When the pupils have obtained their solution, ask them to come back in their groups and present their findings and rationales to each other. Support the class to compare their findings and methodologies.

Final AstroZoo plenary

Invite the pupils to consider how aspects of the fictitious problems that they have explored within AstroZoo might relate to some of the issues we face in sustaining the Earth's environment into the future.

- Which of AstroZoo's problems might apply to the Earth?
- What sort of data might environmental scientists need to know in order to solve some of the Earth's sustainability problems?
- What mathematics might they need to use?

The 'Earth Factsheet' includes a range of facts and figures about our earth's ecosystem. Ask pupils to review the facts and discuss in small groups how the information might be used to think about how the world could be more sustainable.
Pupils could consider questions such as:

- Which of the information is fixed?
- Which of the information can be variable?
- What other information might you need to find out?