A report on two astrobiology outreach activities funded by the Biochemical Society: 'Are we Alone?' And 'Mission to Mars: Operation Greenfingers'.

Activities carried out between September-December 2017

Project Aims

- Create and pilot a **classroom outreach intervention** on astrobiology using inquiry-based learning, as part of an undergraduate final year research project
- Create and pilot **a festival-based workshop** on astrobiology and plants, as part of an undergraduate final year research project

Why Astrobiology?

The Relevance in Science Education (ROSE) project showed that Astrobiology is a STEM subject that both girls and boys in Ireland find equally interesting!

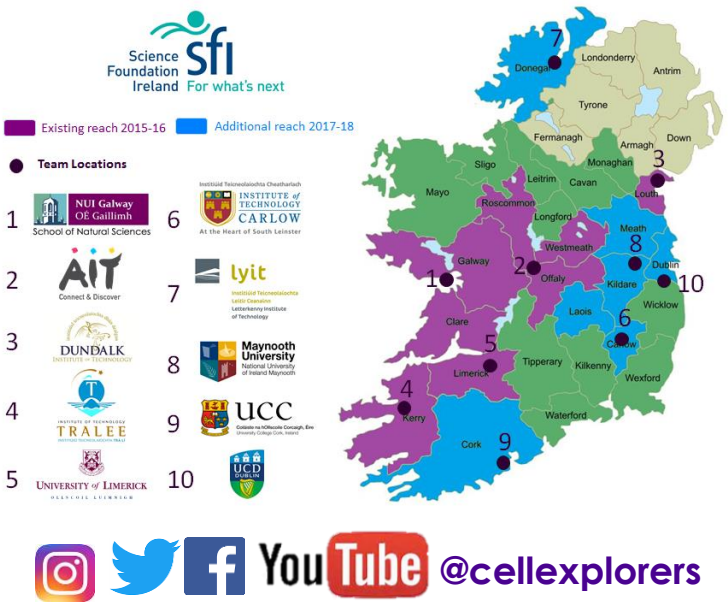
This project was a working collaboration between Cell EXPLORERS at NUI Galway (www.cellexplorers.com) and Blackrock Observatory Castle, Cork (www.bco.ie). Future directions include dissemination of these activities by both the Cell EXPLORERS ten national teams and by Blackrock Castle Observatory

Project Members

Cell EXPLORERS is a science education and outreach programme based in the School of Natural Sciences in the National University of Ireland, Galway. Supported by Science Foundation Ireland (SFI) it has recently expanded to ten teams based in Higher Education Institutes across Ireland.

Directed by Dr Muriel Grenon (NUI Galway) it works on a unique model where volunteers and student projects combine to deliver sustainable hands-on activities suitable for science.

Cell EXPLORERS National Network



@cellexplorers

Blackrock Castle Observatory (BCO) is a science and space centre that aims to "affect positive change in attitudes toward science, engineering and technology in Ireland and be recognised and respected as a centre of excellence in scientific research, education and outreach".

Through innovative workshops and partnership, BCO brings science education alive for students of all ages and are a crucial provider of ongoing science education for teachers. Dr Francis McCarthy is the education and outreach officer at Blackrock Castle Observatory and was the representative of BCO in this project.

Developing the activities as part of a collaborative undergraduate final year project

These two astrobiology-themed outreach activities were designed by two science students as part of their undergraduate final year project at NUI Galway.

The students

Melissa Finnerty is an undergraduate student in the final year of her BSc in Biochemistry at NUI Galway. She designed and piloted the *'Are we alone?'* classroom activity. She wrote about her experiences developing and piloting this activity in a blog for the Biochemical Society on thebiochemistblog.com

Lauren Gillepsie is an undergraduate student in the final year of her BSc in Botany and Plant Science at NUI Galway. She created and piloted the '*Mission to Mars*' classroom activity and helped in the pilot of the adapted workshop version for the Galway Science and Technology Festival.

In September 2017, a meeting was held in Blackrock Castle Observatory to introduce the students to the aims and objectives of the project. Dr Muriel Grenon, director of Cell EXPLORERS, gave a brief outline of the project objectives to the two students.

Sarah Carroll, PhD student with Cell EXPLORERS and awardee of this grant, presented several astrobiology classroom activities that she had previously designed that needed further development.

Francis McCarthy, outreach officer of BCO, presented astrobiology-related outreach activities that the science centre had developed in the past.

Lauren, Francis and Melissa strike a pose outside of the Blackrock Observatory Castle in Co. Cork

The students then visited the science and space centre at BCO to find some inspiration for their projects!

They then had **8 weeks**, starting in September, to design their activities, pilot them and evaluate whether they had achieved their aims and learning outcomes.

Outreach Activity 1: '*Are we alone?*'

An inquiry-based learning classroom outreach activity introducing children to the topic of astrobiology

Activity Details

Time of activity: 60 min
Age group: 10-12 years old (5th/6th class in Irish primary school)
Topics: Astrobiology, planets, space, living things
Setting: Classroom
Organisation of students: small groups of 3-4 guided by one scientist explainer
Pedagogy: Inquiry-based learning (IBL)
Aims:
-Introduce children to the scientific method through inquiry-based learning and by incorporating a role-play element.
-Introduce children to the world and work of scientists

Activity Structure

Introduction presentation (15 min)

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Activity: Design the experiment through IBL (30 min)

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Discuss Results and Conclusions (15 min)

A group of five boys test the temperature of the water added to their yeast , aided by their classroom teacher

Pilot Details

This activity was piloted in October 2017 with 5th classes of two schools:

1) 5th Class (25 children) of Galway Educate Together National School (GETNS), taught by Barry Maguire. GETNS is a urban, mixed, co-ed school.

2) 5th class (6 children) Scoil Sailearna in Inverin, taught by Catrian Ni Fhiannachta, is a rural, mixed, Catholic ethos Gaelscoil (teaching is done through the Irish language).

Evaluative feedback was collected via student and teacher feedback surveys and also via feedback from facilitating scientists.
We thank them again for their help with this and for the excellent feedback they provided!

Are We Alone? Detailed activity description

Introduction presentation (15 min)

Children are introduced to the topic of Astrobiology through an immersive movie that incorporates roleplay. Children are given information on requirements for living things to survive, the solar system and the planets within it, the differences between Earth and Europa (one of Jupiter's ice moons). Via this presentation, children are given their 'mission' i.e. **the experiment aim:** *To determine whether Yeast, a living organism, could survive the freezing temperatures of Europa.* They must act as scientists to complete the mission and send their findings on to 'mission control'

A still shot from the introductory movie clip

Activity: Design the experiment through IBL (30 min)

The classroom is divided into 4 stations of 7-8 children each. Each station is facilitated by one scientist. At each station, the facilitator further divides the children into working groups of 2 or 3 each. Each station had a **box** complete with equipment and resources needed to the design the experiment to investigate the research question.

Melissa asks the children about their experiment design

In the box:

Plastic cups
Thermometer
Plastic spoons
Yeast
Sugar
Worksheets
Pens
Wooden stirrers

Are We Alone? Detailed activity description

This activity is designed to employ **inquiry-based learning.** Each facilitator reminds the children of the research question at the beginning and ask the children to recap the information given in the presentation. The facilitator then invites the children, in their groups of 2-3, to design an experiment that would investigate the research question. They are encouraged to discuss within their groups and to draw out diagrams of ideas. Once their group had decided on their experimental design, they are free to use the items in the resources boxes as saw fit. Children are encouraged to observe their experiments and to discuss results and possible conclusions.

Discuss Results and Conclusions (15 min)

Each student had a **report sheet** to complete including Experiment Aims, Methods, Results and Discussion. Once each station had conducted their own experiments, the presenting facilitator led a classroom discussion on the results generated and the conclusions the children could interpret from them.

What is inquiry based-learning?

Also referred to as the 'inductive' or 'bottom-up' approach, inquiry-based learning (IBL) is a pedagogy where students are given the space and resources to observe, experiment and build on their own knowledge. As opposed to traditional 'top-down' approaches, it is very student-centred (Roccard 2007)

An example of a experimental set-up used by the students; one cup modelling 'Europa' has yeast, sugar and freezing water; the other cup modelling 'Earth' has yeast, sugar and warm water

A group of students use a jumper to insulate an experimental cup

Evaluative Feedback Strategy

Evaluative feedback collection methods:

1) Student, teacher and scientist facilitator paper questionnaires
2) Analysis of students report sheets completed
3) Informal oral feedback from scientist facilitators

Are We Alone? Pilot Evaluative Feedback

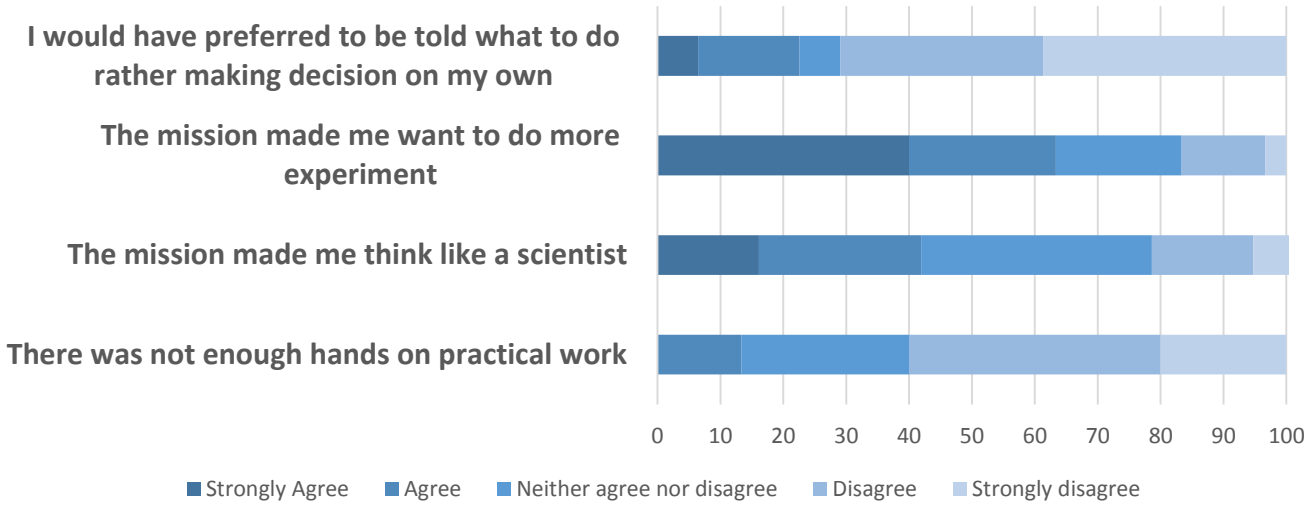
Aims of this activity:

-Introduce children to the scientific method through inquiry-based learning and by incorporating a role-play element.
-Introduce children to the world and work of scientists

Findings from student questionnaires

Children (n=31) were asked to rate using a 5 point Likert-like scale how much they agreed with a series of statements.

42% of children agreed that *The mission made me think like a scientist*
63% of children agreed that *The mission made want to do more experiments*
71% of children disagreed that *I would have preferred to be told what to do rather than making decisions on my own*
60% of children disagreed that *There was not enough hands on work*



Children were asked to choose from a list of words (including Boring, Easy, Too Difficult) which **described the activity best.** Children could tick as many that applied. The most chosen options were: 'Interesting' (chosen by 24 children), 'Challenging' (16) and 'Exciting' (16).

When asked "What part did you enjoy the most?", the majority of children's answers revolved around some aspect of working scientifically:
"Experimenting", "Taking the temperature", "Testing if the mixture worked with the yeast", "Looking at the results"

This suggests **that children enjoyed the hands-on nature of the activity and designing their own experiments** and that the activity was pitched at the right level for the audience.
However, **the majority of children did not feel like they were working as scientists**, which was an overall aim of this activity.

Are We Alone? Pilot Evaluative Feedback Part 2

Findings from scientist facilitator

- Scientist facilitators reported not having had received **enough training** to guide inquiry-based learning.

"...more guiding questions on information about life, Europa and yeast needs to be given to [facilitators]" -Facilitator 1

- They also reported that the students had difficulty deciding whether or not the yeast had respired in the different experimental conditions. This is generally noted as the presence of bubbles or foam when CO2 is produced. However it was found that this was **quite subjective** and some groups had inconclusive results.
- It takes a considerable **amount of time** for the yeast to respire enough to produce detectable bubbles. This limited the amount of times students could repeat the experiment

Discussions and future directions

Although children reported to enjoy the hands-on nature of this activity, the feedback suggests that the **inquiry-based learning aspect of it could be improved**.

The biggest issue was the subjective element to interpreting the results of the experimental conditions. Students were unclear as to whether bubbles were produced and whether the yeast respired.

To address this, the session was further developed by 4th year student Shauna Lyons in spring 2018 **to include the use of a pH indicator (Bromothymol blue) so that the presence of C02 can be more easily detected.** This noticeably improved interpretation of results and also signficantly reduced the time needed to complete the experiment. It also allowed time to repeat experiments if needed, which **strengthened the underlying principle of the scientific method**, and reinforced the idea that experiments in science often don't work out first time and that it's okay to try again!

Although improved, the session is currently undergoing additional design changes and plans to be piloted again in schools in collaboration with Blackrock Castle Observatory September 2018.

Outreach activity 2: *Mission to Mars: Operation Greenfingers*

A quest-like short festival workshop introducing participants to the topic of astrobiology and cultivating plants on Mars

Activity Details

Time of activity: 30 min

Age group: 10-12 years old (5th/6th class in Irish primary school)

Topics: Astrobiology, planets, space, plants

Setting: Festival

Organisation of students: Participants progress through 4 stations in the room at their own pace, assisted by several scientist explainers

Pedagogy: Hands-on activities

Aims:

-Introduce children to the topic of Astrobiology whilst incorporating a role-play element

-Introduce children to the requirements living things need to survive

Introduce children to the concept of extremophiles and the unique abilities that allow them to survive their extreme environments

Activity Structure

Introductory presentation (5 min)

Step 1: Complete the astronomy puzzle to receive a training manual

Step 2: Answer questions in training manual to receive access pass to laboratory

Step 3: Select which leaves inspired by Extremophiles will help your plant survive on Mars

Step 4: Glue leaves to plant.

Step 5: Self-evaluate plant to check whether it survived on Mars!

Pilot Details

(1) Classroom: Piloted by 4th year student Lauren Gillepsie in October 2017 with the enthusiastic 5th class (N=21) of Scoil Chaitriona in Renmore, Galway, taught by Ms Burke. Scoil Chaitriona is an urban mixed catholic ethos Gaelscoil. Evaluative feedback was collected via student and teacher feedback surveys and also via feedback from facilitating scientists.

(2) Festival: The activity was modified by Muriel Grenon and Sarah Carroll of Cell EXPLORERS to suit a festival workshop format. Piloted with 65 children and 43 accompanying adults in the Galway Science and Technology Festival at NUI Galway November 26th. This pilot was also supported by the Galway Science and Technology Festival Bursary in addition to the Biochemistry Society.

Mission to Mars: Detailed intervention Description (workshop version)

The room is set up with different 'stations', through which participants move through at their own pace to complete the different objectives.

Introductory Presentation (5 minutes)

Through a 'mini-movie' styled video, participants are introduced to the theme of the activity, in addition to the workshop aim and necessary background information.

Step 1: (5 min)

At station one at Mission Control the children will first complete a solar system puzzle. This involves the children putting the planets in order from the sun, Earth being the 3rd planet from the Sun and Mars being the 4th. This is done in pairs, 15 puzzles for 30 students.

Solar system puzzle

Astrobiology lab access cards

Step 2: (8 min)

Participants move to station 2, where they receive their Training Manual. At this station, participants read the requisite background information and answer key questions in order to gain their Astrobiology Access Card

Step 3: (5 min)

Participants move to station 3, where they read about 5 different Extremophiles and the unique abilities to possess. They choose foam leaves for their plant corresponding to the unique ability they think would enable their plant to survive the extreme conditions of Mars.

4th year student Lauren explains the different unique abilities of the Wood Frog extremophile

Mission to Mars: Detailed Lesson Description *(Continued)*

Four workshop facilitators pose with the A0 Extremophile boards (THIS TERMINOLOGY IS NLY KNOWN OF US!)

Four examples of Martian Plants designed by the Classroom pilot participants

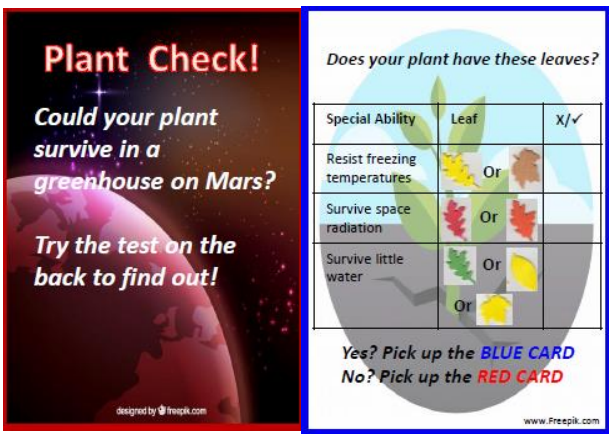
Step 4:

At station 4, participants stick their chosen self-adhesive leaves to their paper plate plant

A young participant at festival pilot sticks her chosen leaves onto her paper plate template

Step 5:

As station 5, participants use Test cards to self-evaluate whether their plant would survive on Mars. Success depends on whether they've chosen one of the correct combinations of leaves available.



Front and back of the Plant Check self-test cards participants use to self-evaluate their designed Martian plant

2 possible results of the Plant Check self-test: Plant does not survive due to inability to survive one or more of the conditions, or plant survives and the mission is accomplished!

Mission to Mars: Evaluative Feedback

Evaluative Feedback Strategy

Feedback was collected using the following methods:

(1) Paper questionnaires completed by workshop participants. Questionnaires were submitted into a draw for a hamper to maximise feedback

(2) Online questionnaires for scientist facilitators administered via Surveymonkey

Unfortunately, the paper questionnaires completed by participants on the day of the workshop were lost after tidying away the materials. As such, only the feedback reported by the scientist facilitators are discussed here. These questionnaires mostly asked about the organisation of the workshop and whether children enjoyed the event.

Scientist facilitator feedback

-All scientist facilitators (5) agreed that the venue was appropriate for the workshop, and that the workshop was well organised and coordinated
-All scientist facilitators (5) reported that the children enjoyed the activity. Reasons included :

"…they engaged well with each step of the activity"
"They were curious and asked for questions"
"…they were not constrained by how much time they need to take or to go to the next steps because it made the activity accessible to a broader range of ages"
"…they were very happy when they designed a plant that could sustain the conditions on Mars"

Suggested improvements included finding a sustainable solution for the leaves in the activity, an alternative to the consumable one-use foam self-adhesive leaves. Another suggested improvement was to include more relevant background information for the workshop for facilitators to more effectively explain concepts to participants (e.g. radiation in space)

Future directions

We are currently looking into a more sustainable solution for the foam leaves. This workshop was delivered again as part of the Youth Academy Programme offered at NUI Galway (https://cki.nuigalway.ie/youth_academy/) on March 3rd 2018. We will continue to improve the quality of scientist facilitator background information in the handbook.