On 16 January 2003, eight Australian spiders embarked on a 16-day mission into space on board the space shuttle Columbia STS-107. The experiment was the culmination of a three-year collaborative programme between students from Glen Waverley Secondary College, RMIT University and the Royal Melbourne Zoo (Thompson et al., 2000), and put the students in direct contact with established space entities NASA, BioServe and SPACEHAB as well as with international researchers.

The students were involved in all aspects of the design of the experiment as well as in investigations into issues such flight clearance and mission simulation.

Despite the tragic loss of Columbia and her crew during the STS-107 mission, the project highlighted the educational benefits of school students being part of a real-life space science project.

Introduction

One of the greatest community benefits resulting from NASA’s space shuttle programme has been education. Examination of previous shuttle missions found there was often excess payload capacity that could be used for small educational experiments. A NASA initiative to make use of this capacity enabled a number of schools in the USA to play an active role in space research.

In the late 1990s, NASA contracted out its commercial space research to SPACEHAB, Inc. This provided an opportunity for SPACEHAB to offer commercial education experimental programmes and resulted in the Space Technology and Research Students (STARS) programme (www.spacehab.com/smi/stars.htm).

‘Spiders in Space’: a collaboration between education and research

An ambitious Australian school project sent spiders into space to experience microgravity. ‘Spiders in Space’ will form the basis of a future project involving many more schools worldwide. Lachlan Thompson and Naomi Mathers, from RMIT University in Melbourne, Australia, explain how it all started.
The STARS experiments flown on STS-107 came from participating schools from the USA, Australia, Canada, Japan, China, and Israel (Goulart et al., 2005).

With the support of scientists and other professionals, each class was responsible for developing their own experiment and liaising with the launch-provider SPACEHAB, the public and other schools.

The research topic chosen for the Australian experiment was ‘Spiders in Space: the effect of microgravity on spider behaviour and web composition’. Spiders had previously flown into space on Skylab 3 in 1973, but the two spiders died before the experiment was completed (Witt et al., 1977). Scientists at RMIT University chose this topic for its accessibility and appeal to students across a broad range of ages and capabilities.

The experiment aimed to add to the current body of knowledge on the biological effects of microgravity on living organisms, with particular focus on web-building and the microstructure of spider silk spun in microgravity. Gravity is believed to have a strong influence on behaviour, particularly on the way they move and build their webs. Gravity is also thought to influence the thickness of their silk and the ‘north-south’ asymmetry of their webs, and to help them to orient themselves, particularly when rebuilding webs that have been disturbed.

The class as a whole developed the mission-specific hypothesis that ‘a spider will build a different web in microgravity than on earth’. This was to be investigated by observing differences in shape, pattern and silk thickness.

The class of 26 Year-9 students (14-15-years old) formed groups to examine the core areas of the project: animal husbandry, habitat development, mission protocols, ‘spidernaut’ training, instrumentation, media and communications.

From the development of the mission hypothesis, each research group set out to conduct a series of experiments to develop the mission specifications. This included selecting the species of spider, spider size and age, lighting, food and feeding mechanisms and habitat features to encourage web-building.

The isolated nature of the experiment encouraged students to anticipate and plan for complications such as spider redundancy (how to carry one or more back-up spiders), failure of the feeding mechanism and whether mechanical or biological feeding techniques should be used.

Students were required to interact with SPACEHAB in the USA through the protocols of experiment approval, hardware definition, live materials list, experimental protocol, ‘delta phase three’ clearance (flight approval), and mission simulation.

‘Spiders in Space’ in the school curriculum

To facilitate the introduction of a major project into the classroom, a curriculum was developed that identified the key topics in the research project and the student tasks which met the educational, teaching and learning objectives for Year 9 sciences. Most of the normal science curriculum (Board of Studies, 1999) could be blended into the project. The project ran with the same students for three years, starting in 2000 and concluding in June 2003. When the students entered Years 10 and 11, the spider project was completed after hours in addition to their normal classwork.

RMIT University and the Zoo provided scientist mentors one day per week for the duration of the project. Team groups met for 30 minutes each week to review overall progress. The spider experiment allowed a wide range of spin-off pre-flight experiments and activities such as:

Students preparing the spider habitat at the Astrotech Facility in Titusville, FL, USA

Team meeting to select the best spidernauts

The habitat with infrared night lighting to facilitate photography of the spider making a web, a biological feeding system and the ability to carry extra spiders

The isolated nature of the experiment encouraged students to anticipate and plan for complications such as spider redundancy (how to carry one or more back-up spiders), failure of the feeding mechanism and
breeding spiders;
• ‘training’ spiders for flight conditions;
• pre-flight environmental conditioning;
• developing and constructing spider habitat;
• developing appropriate lighting for viewing and photographing the webs;
• designing and testing automated feeding mechanisms;
• performing control and flight experiments.

To engage the broader school community, the class commissioned spider habitat boxes from the technology classes, and obtained video cameras and lighting from the electronics classes. A competition was run for Year-11 and -12 students to design the school mission patch.

Results from STS-107 Columbia

The garden orb-weaver spiders (Eriophora transmarina) were monitored day and night with still and video cameras. The night photography was the most useful, as spiders are nocturnal. Excellent images were taken of the spider during its web-making. This allowed the class to examine the spider’s web-making prowess. While eight spiders flew on Columbia, a second spidernaut team was undergoing the control experiment in an identical locker box and habitat on earth. In both habitats, the spidernauts were provided with food by placing fruit-fly larvae in agar gel at the base of their habitat. The flies were recorded on video emerging from their pupae in both the Columbia and the ground control experiment. This biological feeding process was shown to be a viable mechanism to sustain the spiders.

Comparing the performance of the two lead spiders showed that Wako in microgravity was able to construct her web in just over half the time it took her land-based control, Cadbury. A video of Wako shows the spider manoeuvring more deftly on the web than the earth-bound Cadbury. Other observed differences in web shape supported observations made on Skylab 3 (Witt et al., 1977).

During the mission, experimental data were downloaded to mission control and made available to the research team. The Columbia crew worked particularly closely with the student experiments. Israel’s first astronaut, payload specialist Ilan Ramon, released the back-up spiders and took web samples. His observations, comments and insights, trans...
mitted during the mission, conveyed 
his pleasure in working on the experi-
ment and led to a close bond between 
the ‘Spiders in Space’ team and the 
Columbia crew.

Further analysis was thwarted by 
the loss of Columbia, her crew and 
significant data, including the high-
definition images of the spider-webs, 
the spiders and the web samples.

Research and teaching outcomes

The outcomes of the experiment have 
broad applications. Investigation and 
development of life-support systems 
for spiders and similar life-forms in 
space contribute to the knowledge nec-
essary to support ecosystems in space.

Observing how the spiders learn to 
move without the aid of gravity and 
how they develop new techniques for 
web-building provides insights into 
techniques for building structures in 
microgravity. For example, the two-
dimensional nature of the spider-web 
is comparable to the large planar struc-
tures used to support solar arrays.

In developing their hypothesis and 
designing the experiment, the stu-
dents gained insights into the role 
of science in our community. They 
developed individual expertise and 
an understanding of the responsibility 
of scientists to disseminate their find-
ings within the scientific and broader 
community.

The students were required to con-
duct independent research activities 
and apply problem-solving skills to 
real-life situations. Some of the con-
cepts that they encountered during 
the course of the project include:
- the relationship between weight 
perception and the structure and 
microstructure of the web;
- the role of gravity in orientation 
and web-building;
- adaptation to and movement in 
conditions of microgravity;
- the phenomenon of fluid shift 
and other aspects of health in 
space;

‘Spiders in Space’ will be 
followed by a much larger 
space experiment, ‘Bees in 
Space’. Expressions of inter-
est are being accepted from 
schools worldwide. To find 
out more about the project, 
contact Naomi Mathers at 
naomi.mathers@rmit.edu.au, 
or Lachlan Thompson 
at lachlan.thompson@ 
rmit.edu.au.

In future issues of Science in 
School, you can read about:
- how the ‘Spiders in 
Space’ project was 
developed as an inter-
disciplinary project 
between a school, a 
university and a zoo;
- how to get involved in 
‘Bees in Space’, the new 
worldwide project.
This interesting and informative article describes a three-year educational project between scientists and school pupils that was set up to investigate the influence of gravity on spider silk and web-making.

Students worked and met with scientists, which enabled the students to understand and appreciate the wide range of skills that are involved in setting up a project, for example design technology, information technology and biological knowledge. Students were encouraged to develop experimental-design skills that included learning the importance of pilot experiments to test methodology and equipment. The use of live subjects and the loss of the Columbia mission showed the students how frustrating research can be.

The project provides examples of how the school science curriculum can be extended and how novel projects can be incorporated successfully within a national curriculum. Students could be set the challenge of designing similar novel experiments via group work and/or classroom discussion or applying to participate in the ‘Spiders in Space’ project. This would stimulate their imagination, a prerequisite for carrying out novel research, and would show how scientists in different subject areas need to collaborate for a successful outcome.

The article may be linked to other topics in biology, for example, the different types of spider silk, the effect of drugs on spiders and web production, and problems associated with breeding programmes such as genetics or habitats. This would broaden the horizons of students and teachers and may encourage them to be more curious about the world.

Shelley Goodman, UK