International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION

Access to Space for Stem Education Inspiration through Ice Cubes

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Abstract

Space is considered as the ultimate summum of inspiration for topics in Science, Technology, Engineering and Mathematics (STEM) education. The International Space Station (ISS) is one of the most powerful and inspiring scientific laboratories, placed in one of the most unique and least explored environments on and around our Earth and covering the widest ranges of research disciplines under one roof. This is a huge attraction for both scientists and educators, but unfortunately the use of the ISS has been until now unattractive for a large number of potential users due to the burden of complex rules, procedures, cost and duration associated with developing, certifying and operating equipment on board. Recently the International Commercial Experiment Cubes (ICE Cubes) service has been put in place as first such service in Europe to provide now fast, simplified and affordable access to the ISS under a public/private partnership with the European Space Agency. The ICE Cubes service supports the end-to-end process of experiment development and takes care of the certification for flight, launch and installation on board. This is in particular of high interest for STEM educational purposes. Once the experiment is installed in the ICE Cubes Facility the students can operate it directly from their schools via internet. Schools or classes develop their own space Experiment Cubes according to a specific set of requirements. The other interesting aspect is that the use of ICE Cubes in educational scopes allows for covering all phases, from the conception of a scientific or technological experiment to the initial design concept, to the development of the hardware and software, to real-time data gathering and related analysis afterwards. This paper will describe in detail the different possibilities in which ICE Cubes can be used for education from use in a single classroom on primary or secondary level to Master or PhD projects, from single schools to intra-school sharing concepts, and in connecting the 'knowledge triangle' of business, education and research. All this with the fascination of doing science in space is an unbeatable motivation trigger for STEM education.

Keywords: ISS, Education, ICE Cubes, STEM, Space Experiment, Space Applications Services

1. Research and education on ISS

Fascination for Space has always existed, from our ancient ancestors looking up at the stars, drawing out constellations and using them for navigation, to igniting the creativity to actually building those spaceships that allow us to go out and explore the vast Universe. The International Space Station (ISS) is one of the most iconic results of this fascination and curiosity for Space which also led to one of the biggest human international collaborations. The ISS has many objectives [1]:

- To act as a manned Earth-orbiting laboratory for carrying out long-term scientific research in the unique environment of space;
- To accelerate innovations in technology and engineering with resulting applications on Earth;
- To study the effects on humans of working and living in space for long periods of time, thus acting as a stepping-stone to future human explorations of the Moon, Mars and beyond;
- To promote partnerships between industries, research institutes and educational entities;
- To promote the image of science and engineering, influencing the educational paths chosen by future generations;
- To sustain and reinforce the highly technological aerospace industry;
- To satisfy the age-old human nature of exploration.

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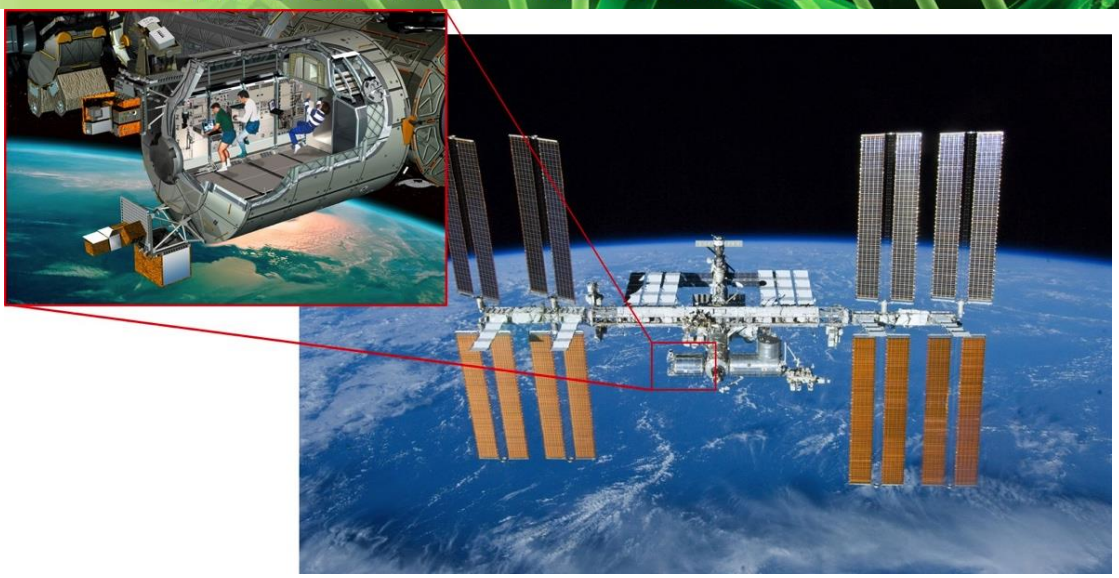

Figure 1: The International Space Station with a cut-away artist impression of the European Module, Columbus [Credit:ESA/NASA]

The international partners that created the ISS are the USA, Europe, Russia, Japan and Canada, but many more countries are involved in the endeavour. Every country contributed with resources, expertise and by building part of the Station itself. One of the main European contributions is the Columbus Module, a scientific laboratory for research in many different fields such as for example Biology, Fluid science and Human Physiology (Figure 1).

The access to the ISS's facilities, nevertheless, has been restricted in the past to institutionally funded academic research groups that needed the field of microgravity to advance in their research and had the money and time to dedicate for preparing experiments on the ISS. Indeed, in the past, wanting to do an experiment on board of the station was paired with a process of call for proposals followed by complex rules, procedures, cost and long durations associated with the development, certification and operations of the equipment on board of the station. This complex process often resulted in discouraging potential users (including schools which usually have limited resources) from proposing experiments access the ISS for educational purposes, even if the fascination for Space could be used as a great asset for the stimulation of children's interest towards STEM disciplines. This does not mean that in the past, the ISS was void of educational projects. Several educational programmes have been put into place by ESA and other international agency partners to which schools could apply to participate. Nowadays, changes are happening as the International Commercial Experiment Cubes (ICE Cubes) service has been put into place, under a public/private partnership with the European Space Agency, as first such service in Europe to provide direct, fast, simplified and affordable access to the ISS. This new way of accessing the assets of the ISS opens up a new approach and opportunities that can enhance the educational material for STEM related subjects. This paper is presenting the ICE Cubes Service and explain how this service can bring an innovative way of motivating children and teenagers to study STEM.

2. ICE Cubes Service

ICE Cubes is a commercial service that is providing regular, fast, simple and affordable access for small experiments to the International Space Station (ISS). The overall ICE Cubes Facility will be accommodated inside the European module of the ISS. Inside this facility, up to 20 single "plug-and-play" Experiment Cubes can be installed, each of them hosting an experiment designed and developed by the user (Figure 2). The Experiment Cubes have standardised physical and operational interfaces. Each Experiment Cube may be built from commercial off-the-shelf (COTS) components, which significantly lowers the cost and duration of development and allows for the utilisation of the most recent technologies. This approach greatly reduces complexity and allows academia, schools, industry and the general public to develop and build Experiment Cubes for the ISS.

The ICE Cubes Service created by Space Applications Services offers guidance during the development of the Experiment Cubes and provides the service of launch dates, interface testing, arranging experiment certification, launch and on-orbit installation, operation and the possibility to return if so wanted.

Figure 2: ICE Cubes in different sizes (left); ICE Cubes Facility inside the Columbus Module (center); Astronaut Hans Schlegel working inside Columbus Module (right) [Credits: Space Applications Services/ESA]

3. ICE Cubes for education

The aim of using ICE Cubes for education is to stimulate the curiosity of students in STEM fields at primary / secondary level through the excitement for space and human spaceflight. To achieve this, ICE Cubes could be used in different ways by different age-groups and different schools in different countries or at different demographic level, in order to accommodate for the wide variety of science curricula or teaching level that can be found across the whole of Europe for example.

3.1 Designing & building your own ICE Cubes

The first way in which ICE Cubes could be used for education is for the user to pursue the whole development process of a scientific experiment in Space with the support from the ICE Cubes Service. The different steps that they would follow and experience in this case are:

1. The definition of the science objectives of their educational experiment. Here the students are taught about microgravity and Space, after which their imagination will allow to propose experiments to be executed on the International Space Station.
2. The design of the Experiment Cube. From the experiment idea and a simple set of requirements, the details of the experiment concept and structural design will be established.
3. The actual development of a cube, possibly using existing commercial off-the-shelf (COTS) components. This development can either be done by the school themselves or a collaboration can be set-up with higher-age groups and/or industrial developers' teams.
4. Ground Testing. All the features that were created to build the experiment will have to be tested, partially at the user's premises and partially at Space Applications Services
5. The experiment shipment to the launching facilities. Once the experiment is ready and tested, it can be packed and shipped to go the rocket that will bring it to Space. An exciting moment for the students and teachers!
6. The launch to the ISS. It will be possible to follow the launch live from the user's premises.
7. Experiment installation. Once the Experiment Cube has arrived on-board of the ISS, a crew member will install the cube into the ICE Cubes Facility.
8. The Operations. After installation, connection with the Experiment Cube will be established and the real-time control and gathering of data will be possible to be done directly from the classroom. ICE Cubes Services will provide an out-of-the-box software suite to do so.

3.2 Operating an existing educational ICE Cube on-board of the ISS

The second way in which ICE Cubes could be used for education is by schools to be granted access to a set of pre-installed educational Experiment Cubes on the ISS that were built by ICE Cubes Service. In these flagship Experiment Cubes, a number of educational scientific experiments will be

placed covering several STEM subjects, such as coding, cell biology or foams in microgravity. Schools or individual classes would be "renting" time and would be able to access the Experiment Cubes directly from their classroom, control and monitor the experiment and gather a small set of data to be analysed in class afterwards. This option would greatly simplify the process, the needed time involvement and the to-be-covered material for the involved teacher and class.

Figure 3: Representation of the testing of ICE Cubes Experiment Cubes (left and centre) and the operations from the main control centre (right) [Credits: Space Application Services]

3.3 One portal to access space for STEM education related to human spaceflight

The development of an online portal will be started on which all the information can be found needed to start using the excitement of the direct access to the space station from the classroom as offered by the ICE Cubes Service. This portal will be filled with educational resources to be used by teachers, but will also provide resources and material accessible to all which can be followed on a personal basis from home.

Another aspect of the portal will be to create a platform on which schools, universities, research centres and industrial partners can connect and create cubes together or exchange information. This part of the portal will thus cover and bring to life the "knowledge triangle" and knowledge transfer that is often missing in the education and the society of today. This facet of the portal could then furthermore be used for schools to pursue sponsorships and/or collaborations with academic and industrial entities.

4. Conclusion

As described throughout this paper, the ICE Cubes Service provides a direct and simplified access to do science experiments on-board the ISS. It is believed that this novelty way of accessing Space has a great potential to enhance the education of and interest for STEM related subjects. Especially as the service is open to all as it is adaptable to different schooling levels (primary, secondary, university), different STEM curricula, within intra-school or intra-level collaborations or even by involving the support and cooperation of research and industry. Moreover, by putting ICE Cubes Service in place for young generations we contribute to a wider European goal of:

- Support to the teachers and students to learn about the exciting aspects of space research;
- Stimulate creative and autonomous thinking, cooperation, teamwork and inclusion;
- Establishment of the "knowledge triangle" and closing the gap between academic, industry and educational entities.

References

[1] UIC-ESA-UM-001 Issue 2 Revision 0, European User Guide to Low Gravity Platforms, Erasmus User Centre and Communications Office, Directorate of Human Spaceflight, Microgravity and Exploration Programmes, ESA, September 2005;