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NASA EDUCATION ACTIVITIES ON THE INTERNATIONAL SPACE STATION: A NATIONAL LABORATORY FOR INSPIRING, ENGAGING, EDUCATING AND EMPLOYING THE NEXT GENERATION

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ABSTRACT

The International Space Station (ISS) National Lab Education Project has been created as a part of the ISS National Lab effort mandated by the U.S. Congress The project seeks to expand ISS education of activities so that they reach a larger number of students with clear educational metrics of accomplishments. This paper provides an overview of several recent ISS educational payloads and activities. The expected outcomes of the project, consistent with those of the NASA Office of Education, are also described.

NASA performs numerous education activities as part of its ISS program. These cover the gamut from formal to informal educational opportunities in grades Kindergarten to grade 12, Higher Education (undergraduate and graduate University) and informal educational venues (museums, science centers, exhibits). Projects within the portfolio consist of experiments performed onboard the ISS using onboard resources which require no upmass, payloads flown to ISS or integrated into ISS cargo vehicles, and ground based activities that follow or complement onboard activities. Examples include ground based control group experiments, flight or experiment following lesson plans, ground based activities involving direct interaction with ISS or ground based activities considering ISS resources in their solution set. These projects range from totally NASA funded to projects which partner with external entities. These external agencies can be: other federal, state or local government agencies, commercial entities, universities, professional organizations or non-profit organizations. This paper will describe the recent ISS education activities and discuss the approach, outcomes and metrics associated with the projects.

INTRODUCTION

Education has always been an important component of the NASA mission. The genesis of today's NASA Office of Education is contained within the founding legislation of the Agency, the Space Act of 1958. In recent years, the NASA Authorization Act of 2005 (Public Law 109-155, 30 December 2005) provided the Agency with U.S. Congressional direction to "…seek to increase the utilization of the ISS by other Federal entities and the private sector through partnerships, cost-sharing agreements or other arrangements that would supplement NASA funding of the ISS." In 2007, as part of the 21st Century Competitiveness Act Conference Report, the Agency received additional direction to use the ISS National laboratory to support science, technology, engineering and math (STEM) education.

Conducting educational related activities on NASA human spaceflight missions or from onboard the ISS is not a new concept A host of educational activities and educational payload operations have been conducted as NASA sponsored activities or as activities sponsored by the ISS Program International Partner space agencies. Previous ISS related educational activities have involved an over 31 million students worldwide in just the first 6 years of permanent occupation of the ISS (Ref. 1). What is new and different is the U.S. Congressional mandate to incorporate education as part of the ISS National Laboratory effort. Specifically, NASA has been given Congressional direction to pursue activities which leverage the resources of entities external to NASA, including commercial companies, academic institutions, not-for-profit organizations and other U.S. Government agencies. Collaborative educational activities directly partnered with, or in conjunction with, the ISS Program International Partner space agencies will also be included in this expansion of ISS educational activities. The partnering mandate is seen as a force multiplier for the ability to conduct ISS related educational activities.

ACTIVITIES OVERVIEW

In conjunction with the ISS National Lab Education Project, the traditionally successful educational projects and payloads, such as those managed by the Teaching from Space Office at the NASA Johnson Space Center, are expected to continue. Payloads and activities such as Earth Knowledge Acquired by Middle School Students (EarthKAM, Earth Knowledge Acquired by Middle School Students, Sally Ride, Principal Investigator), Amateur Radio on ISS (ARISS, Amateur Radio on the International Space Station, Kenneth Ransom, N5VHO, Principal Investigator, JSC Education Office) and ISS Education Downlinks (Cindy McArthur, Principal Investigator, JSC Education Office) have had a lengthy history of successful operations and have involved hundreds of thousands of students throughout the world. Table I and Table II presented at the end of this paper document the numbers of schools, by country, that have participated in the ARISS and EarthKAM activities, respectively.

Under the ISS National Lab and ISS National Lab Education Project concept, payloads such as the Commercial Generic Bioprocessing Apparatus (CGBA) Science Inserts (CSI, Bioserve Space Technologies, Louis Stodieck, Principal Investigator), the Synchronized Position Hold Engage and Reorient Experimental Satellite (SPHERES,) and Space Dynamically Responding Ultrasonic Matrix System (Space-DRUMS, Jacques Guigné, Principal Investigator) are poised for additional partnering opportunities and expansion of their educational activities. Some of these payloads will expand their educational scope to incorporate content applicable in the both the Kindergarten through 12th grade (K-12) as well as at the University level (undergraduate through post-graduate grade levels). Activities to further incorporate international student participation as well as students from traditionally underrepresented and underserved institutions will also be emphasized.

Commensurate with these goals, the NanoRacks ISS National Lab payload (also known as CubeLab, Jeffrey Manber, Principal Investigator) is now offering flight opportunities for K-12 schools and Universities to conduct experiments of their own design within the NanoRacks facility. In March 2010, the Valley Christian School of San Jose, California purchased a Nanorack insert to conduct an experiment designed by their students. Similar University-level contracts as well as purchase agreements involving student organizations outside of the United States are anticipated shortly. The NanoRacks /CubeLab hardware is developed by Kentucky Space, an ambitious non-profit enterprise focused on R&D, educational and small entrepreneurial and commercial space solutions involving several Universities in the state of Kentucky. The Kentucky Space model contains student involvement at all ends of the supply chain: from the development of the NanoRack/CubeLab host flight hardware to student involvement in the development and operation of an experiment sponsored by the payload customer school.

Fig. 1: NASA Astronaut Shannon Walker works with the NanoRack/CubeLab payload onboard the ISS.

The SPHERES payload is continuing as a workhorse for both educational and professional payload customers. The SPHERES satellites operate inside the modules of the ISS under the supervision of an ISS Astronaut. They use pressurized carbon dioxide for propulsion and have configurable software and docking hardware for testing. College students use them to test new ways to control satellites. In the Zero Robotics competition, SPEHRES is used to for educational goals. Zero Robotics enables middle and high-school students not only to observe space science and engineering, but to be part of it. As part of a robotics competition, students program their satellites for autonomous operations. After the students complete their software they watch as they see whether their programming works to achieve their objective. The satellites race against each other to perform a relevant engineering task. The races takes place in simulation at the Massachusetts Institute of Technology and then onboard the ISS. In August 2010 as part of NASA's Summer of Innovation program, with funding provided by the Massachusetts Space Grant, middle school students from 10 schools and educational groups were involved in a SPHERES competition. The SPHERES satellites simulated the assembly steps of a larger satellite. They first navigated through virtual obstacles, reached a docking location (for example, where a new virtual part would be picked up), and then went to the finish area where the virtual part would be assembled. The middle school students were required to program the satellite to perform these steps autonomously, without any human intervention after the NASA Astronaut Shannon Walker started the tests (Ref. 2)

Fig. 2: The SPHERES internal satellites flying inside the ISS under the control of student developed software

The CGBA Science Insert payload is currently preparing for its next set of CSI student science experiments, after the resoundingly successful CSI-4 "Butterflies in Space" exeperiment. Painted Lady butterfly larvae completed their lifecycles in a habitat contained inside of the CGBA payload onboard the ISS. Over 180,000 students were engaged in classroom based control group experiments using a standard habitat design. Students participated in the CSI-4 mission by conducting their own open-ended investigations of the growth, development and behavior of the butterflies growing in microgravity conditions, while comparing these to similar butterflies under the normal gravity conditions of their own classrooms. Butterflies in Space was developed by BioServe Space Technologies, a component of the University of Colorado, in conjunction with the Baylor College of Medicine and the National Space Biomedical Research Institute (Ref 3).

Fig. 3: The CSI-4 experiment - Monarch butterflies inside of their habitat contained within the CGBA ISS Payload.

Not all student experiments have involved the use of sophisticated payload hardware onboard the ISS. The Kids In Micro-g design challenge (Debbie Biggs, NASA Education Office, Principal Investigator) was developed with the opposite in mind. Given a set of set of simple items commonly found in classrooms as well as onboard the ISS, 5th through 8th grade students were asked to develop a microgravity experiment or demonstration that would have an observably different outcome from the classroom when performed by astronauts in the microgravity environment of the ISS. A series of 9 student developed experiments were selected for execution onboard the ISS. The materials used ranges from rubber bands, to a pen and paper, pen caps, empty shampoo bottles, fruit drink and hot sauce. The experiments were designed to examine phenomena associated with projectile motion, microgravity interaction of objects, fluid mixing and absorption and Astronaut adaptability to microgravity.

Kids In Micro-g was rolled out as part of the informal education activities of the Buzz Lightyear™ on ISS public outreach activity. In conjunction with the latter, two special feature videos of “Buzz Lightyear’s ISS Mission Logs” were included in the recent re-release of the Toy Story™ 1 and Toy Story 2 DVD movies. The Disney/Pixar special feature videos, written in consultation with staff from the ISS Program ISS National Lab Education Project, targeted younger audiences with explanations of the basic concepts of spaceflight, the construction and operation of the ISS, life onboard the ISS, and research being done on the ISS.

Fig. 4: Buzz Lightyear™, the inspiration for the Kids In Micro-g Challenge and the host of the Buzz Lightyear ISS Mission Log special feature videos produced by Disney/Pixar.

Not all education onboard the ISS occurs inside the pressurized modules. Student developed Cubesat (nanosat class) satellites have been deployed from Space Shuttles after undocking from the ISS. One such Cubesat under the ISS National Lab purview was the Dual Radio Frequency Astrodynamic Global Positioning System (GPS) Orbital Navigation Satellite (DRAGONSat), developed jointly by the University of Texas and Texas A & M University . The objective of DRAGONSat was to demonstrate GPS based autonomous rendezvous and docking using a pair of cubesats. A follow on mission is currently under development by these universities. Additional Cubesat launches associated with ISS missions are anticipated when the SpaceX Dragon ISS commercial cargo vehicles become operational.

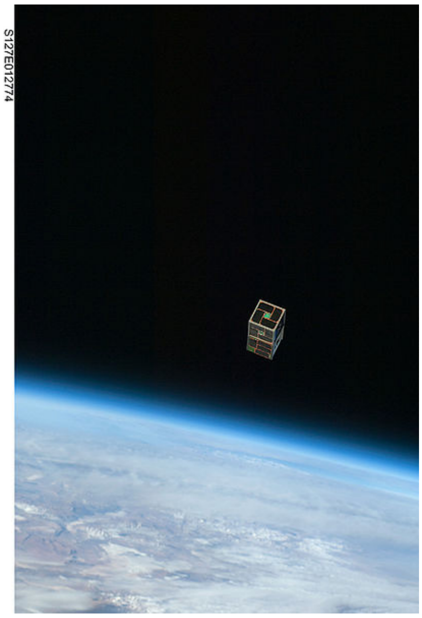

Fig. 5: DRAGONSat deployment from Space Shuttle Endeavour on mission STS-127 after undocking from the ISS.

ISS Educational satellites in the larger microsat class, are also under development. The Radio Amateur Satellite Corporation (AMSAT), the hardware provider for the ISS HAM payload which is used for the ARISS school contact activity, is developing ARISSat, an educational satellite with the capability to carry 4 to 5 student developed experiments. In addition to providing a space communications utility for use by amateur radio operators worldwide, ARISSat can provide data telemetry from its onboard student experiments via amateur radio links. ARISSat is being developed in conjunction with RSC-Energia and the ISS National Lab Education Project.

ARISSat-1, the first of a planned series of ARISSat satellites, will be launched to ISS in late 2010. It will then be manually deployed by ISS Cosmonauts during a spacewalk currently scheduled for February 2011. Aboard ARISSat-1 is an experiment from Kursk University in Russia, to derive atmospheric density measurements in situ based on readings from an onboard pressure sensor. The objective is to obtain these in situ measurements daily from the experiment's pressure sensor. Experiment telemetry will be downlinked via amateur radio, until the satellite's orbit decays and the satellite is destroyed during re-entry.

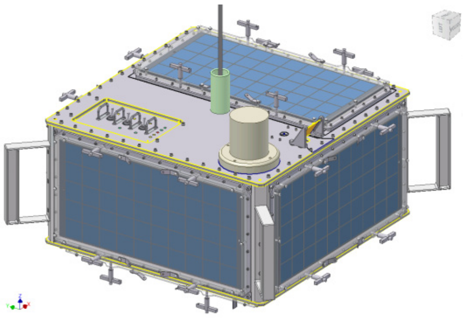

Fig. 6: A drawing of the ARISSat-1 educational satellite. The Kursk University experiment is the gray cylinder in the lower most corner of this view.

Not all ISS educational activities focus on the operation of an experiment on or around the ISS. The High Schools United With NASA to Create Hardware (HUNCH) program (Stacy Hale, Project Lead) is an activity where middle school and high school students build flight and training hardware for use in the ISS program. HUNCH currently involves over 20 schools in 8 states. Mentored by professionals from the NASA team, students participate in all aspects of the hardware design and fabrication. The hardware fabricated has ranged from cargo transfer bags used onboard the ESA's Automated Transfer Vehicle (ATV) ISS cargo spacecraft, to training hardware for avionics equipment used in the ISS simulators at the NASA Marshall Space Flight Center and the NASA Johnson Space Center. NASA currently funds the HUNCH program, and realizes a significant cost savings due to the production of professional grade hardware required for ISS operations at essentially a materials-only cost. The program is currently being expanded to the United States Military Academy, where West Point cadets will gain project management experience while managing the production of ISS training hardware that will be fabricated at several middle schools and high schools in the state of New York.

Fig. 7: NASA Associate Administrator for Space Operations William Gerstenmaier accepts delivery of ISS training hardware from the Clear Creek Independent School District

EDUCATIONAL OUTCOMES

The ISS National Lab Education Project continues to expand opportunities for STEM education for students from the Kindergarten to Post-Graduate levels, using the space station as a catalyst to engage students. The partnering opportunities enabled by the ISS National Laboratory will provide new ideas and resources for ISS program related educational activities and payloads.

At its core, the project strives to allow for participation the ISS mission by the world-wide public, educators and students (Tables I and II). Consistent with the goals of the NASA Office of Education (Ref. 4), the project will continue to develop a portfolio of STEM (Science Technology Engineering and Mathemqatics) education activities with the expected outcomes of:

- Developing the next generation of STEM workforce in disciplines needed to meet NASA's strategic goals
- Attracting and retaining students in STEM disciplines through a progression of education and research opportunities for students, formal and informal educators and faculty.
- Building strategic partnerships and linkages that promote STEM literacy through formal and informal educational opportunities

In doing so the ISS National Lab Education Project will serve as an educational resource for educators, students and life-long learners world-wide for the duration of the ISS Program.

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2. Press Release: "NASA Summer of Innovation Zero Robotics SPHERES Summer Program, 2010-08-19", Massachusetts Institute of Technology

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Acknowledgements
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Country	No. of Schools
Australia	29
Belgium	32
Brazil	4
Canada	43
Croatia	1
Ecuador	1
Finland	3
France	14
Germany	13
Greece	3
Hungary	2
Ile de La Réunion	1
India	5
Ireland	1
Israel	1
Italy	34
Japan	46
Kuwait	2
Malaysia	7
Mali	1
New Zealand	3
China	3
Peru	2
Poland	3
Portugal	4
Republic of Korea	2
Russia	23
Senegal	1
Slovenia	1
South Africa	4
Spain	4
Sweden	2
Switzerland	6
Taiwan	1
Thailand	2
The Netherlands	6
Turkey	2
United Kingdom	14
USA	*222*
Total	*548*

Table I. Number of schools, by country that have participated in ARISS school contacts, as of August 2010.

Country	No. of Schools
Argentina	9
Australia	1
Belgium	1
Brazil	1
Canada	14
Chile	1
France	2
Germany	11
India	2
Japan	31
Mexico	4
New Zealand	1
Republic of Korea	4
Spain	8
United Kingdom	5
United States	1164
Total	1259

Table II. Number of schools, by country that have participated in EarthKAM missions, as of April 2010.