SPACE EDUCATION SPECIALIST: BRIDGING THE GAP BETWEEN EDUCATION AND PUBLIC OUTREACH

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ABSTRACT. Education and Public Outreach (E/PO) are vital in connecting society with the benefits that come from the development and application of space knowledge, science, and technology. E/PO are often cited together as if they were the same entity but education is different from public outreach. With these two terms clearly defined as a starting point, an educational initiative called the Space Education Specialist (SES) is proposed with three fundamental building blocks to make this a viable course of action for space faring nations. First, a business plan is documented for the SES that identifies partnerships among educational institutions, industries and space agencies in a mutually beneficial setting. The next component is a five-year plan in which educators receive specific astronaut training, create curriculum resources with space as the vehicle of instruction and network with other space professionals before and after returning to the classroom. Finally, the concept of "*intentional education*" uses Space as a common theme during the impressionable ages of 11 to 14 in a concurrent teaching approach. The SES is a long-term solution that bridges the gap between education that increases scientific literacy and public outreach that promotes the societal benefits of Space.

INTRODUCTION

Education and public outreach form some part of any space initiative whether it is the launch of a national satellite or an attempt by Canadian Brian Feeney and his DaVinci team to win the private enterprise Ansari X prize. Although they are treated as one entity and often funded as a single item, education is not the same as public outreach. A gap exists between the two, perhaps because of assumptions being made by the aerospace industry that the public is able to effectively educate itself as the recipient of outreach activities. This proposal makes a clear distinction between education and public outreach, and outlines an educational initiative called the Space Education Specialist (SES). The SES plan will coordinate educators, teacher federations, and provincial ministries of education, the national space agency and an international governing body. A unified approach is essential if increasing scientific literacy in our youth and in the general population is to be a global reality. The SES can bridge the gap and result in a more scientifically literate society, with a public that uses this knowledge to make informed decisions for a successful future.

Education and Public Outreach are Different

Definitions

The Aerospace industry often clashes with public perception, as do most scientific or technological institutions. Until the average citizen can explain why space science and technology are significant to society this problem will persist and be manifest in choices made with regard to support for space initiatives. The 2003 Canadian Federal budget did not allocate any new money to the Canadian Space Agency to support the Mars Science Laboratory. The role of public outreach and education is vital in connecting the community at large with the benefits that come from the development and application of space knowledge, science and technology. In current literature there are no rigorous definitions to

differentiate between the two, which is the inherent problem for education and public outreach (Morrow et al., 2002). Public outreach is different from education. It is a mechanism that is short term and information based, being quantifiable only in the number of people who are exposed to the desired knowledge. It excites interest, arouses curiosity and often has an element of entertainment. It usually coincides with a large-scale event that is more likely to create public interest. Public outreach products and services can be science articles in the mass media, television and radio programs or Internet events. It may require only a limited commitment on the part of the individual or group because a person need not move from home to access the outreach event.

Education, being more long term, is better able to change behaviour and influence choices. With education, quantifiable learning takes place. Its products are found in the classroom, which requires curriculum growth, professional development of teachers, and support for reform within the context of the educational system. Education necessitates a greater commitment by the public because it forms part of the student's worldview.

Public Outreach Activities

Current examples of outreach programs include efforts by the Canadian Space Agency, the European Space Agency and the Australian Powerhouse Museum. Canadian Space Agency astronaut Col. Chris Hadfield spoke in Canada at the University of Guelph, *Farm Smart* conference last January 2004. Hadfield was raised on a farm and was an ideal featured speaker for the conference sponsored by the Ontario Agricultural College, Ministry of Agriculture and Food, soil and crop improvement associations and businesses. People from the farming culture of southern Ontario were exposed to a very positive view of Space and left feeling that there was a connection between "somewhere out there" and their everyday world of farming.

The European Space Agency (ESA) ran a successful series of tests in Europe promoting the famous "Rosso Corsa" paint that Ferrari uses on their race cars. Following Michael Schumacher's fifth Formula 1 driver championship title in 2002, the Ferrari team agreed to fly the symbol of its success, a sample of the distinctive red paint, in a special container on the European Space Agency's Mars Express mission to the Red Planet. The link with Ferrari was an intentional move by ESA to get more Europeans interested in space. Formula 1 fans could identify with the speed that the Mars Express needed to get to Mars: 10,800 kilometres per hour (6,700 miles per hour), much faster than any Grand Prix car but none the less a connection point with people and their passions.

The Powerhouse Museum, Australia's largest and most popular museum, is located in Darling Harbour, Sydney. Its collection of 385,000 objects is unique and draws from history, science, technology, design, industry, decorative arts, music and transport. Its space exploration exhibits highlight the history of the human desire to travel beyond the Earth’s atmosphere. As an informal venue, the Powerhouse Museum reaches out to interested members of the public with interactive exhibits. Teachers and their students can participate in Powerhouse Discovery Challenges conducted in the classroom with activities that are linked to the curriculum. The museum boasts one million visitors annually and measures its success as a government sponsored organization by its admission numbers.

These examples of public outreach involve connecting with only a segment of the population in familiar situations of their choosing: their daily jobs or professions, their hobbies or areas of specialized interest. In all three examples people are made aware of space and may appreciate its importance. However, do they support it on a larger scale that goes beyond their immediate situation and how can a greater portion of the whole population be reached? Such support for space initiatives is difficult to achieve with public outreach.

Measuring the Success of Public Outreach

In a 1998 survey conducted by the European Space Agency (Peeters, 2000) using a telephone inquiry by an independent company, it was found that:

- 42% of the respondents had an interest in space exploration
- 63% thought that a national space program was important
- 12% recognized ESA as the European Space Agency
- 54% immediately knew what NASA was as an organization

It appears that Europeans value space programs but perhaps this is due to NASA visibility and not ESA promotion. In his book *Space Marketing*, Walter Peeters uses a theoretical model that outlines an effectiveness factor [E] for public outreach :

$$C = \frac{T}{N} \cdot E$$

C = Cost of communication per person reached

T = Total cost of the communication effort

N = Number of people reached

E = Effectiveness of outreach

This equation identifies the number of people exposed to the desired information and the costs of such communication but it does not express whether or not the behaviour or perceptions of the public have been changed. It is difficult to measure a qualitative property like effectiveness when using quantitative numbers such as cost.

Education Programs

Education has a different audience and a different purpose compared to public outreach. For example, the Canadian Space Agency has an excellent education based program entitled "Tomatosphere". Students grow tomato plants from three different types of seeds. They learn about a control group, a second seed group that has been exposed to a Mars environment analogue and other samples that have been exposed to a simulated Mars greenhouse environment. Watching these seeds grow helps answer important questions about the requirements for long-term space missions. It is imperative to know how to grow food, recycle water, and exchange oxygen and carbon dioxide if astronauts are ever to journey to Mars. Through this course of study, students learn how to conduct experiments and are inspired to pursue further education opportunities in science and technology. As an educational program this project became part of 5000 classrooms across Canada. Students in two age groups, grades 3 to 6 (ages 8-10) and grades 8 to 10 (ages 13-15) were given tomato seeds from the Heinz Company of Canada to grow under prescribed conditions. Results were sent electronically to the Tomatosphere website at www.tomatosphere.org to be posted for all participants to see in other classrooms across the country. One of the most influential aspects of the Tomatosphere project is its plan for continuity. Each year a consortium will develop school projects for teachers and students based on germination and growth of tomatoes exposed to different conditions such as extreme environments that are analogous to Mars or onboard the International Space Station (ISS).

A similar educational project was launched by the European Space Agency. This project gives students hands–on experiences with satellite data through the "Eduspace" site (ESA, 2004). Designed in 2001 to give youth an idea of how satellite data are used, the site is now accessed by schools in 67 countries worldwide. Students can use actual earth observation data to see how satellite images can be used to identify landmarks, find out more about distant countries or study local weather patterns. Earth observation data are multidisciplinary, having applications in a number of European languages for studies of the environment with land use, climate change, natural disasters and animal migration patterns. To ensure that the project remains relevant to current curriculum, Eduspace organizers solicit the feedback of teachers on the type of material they find most useful.

Most space agencies have some form of teacher training. The most extensive to date is the NASA Education Mission Specialist program which replaced the American Teacher in Space Program that tragically ended with the death of Christa McAuliffe and 6 other astronauts in 1986. This program addressed NASA's desire to better connect with the public by sending a civilian into space. Christa McAuliffe as a teacher qualified as a civilian who could spend a year or more training as an astronaut and then after one flight return to the classroom. It is interesting to note that after exploring the possibilities of sending a journalist, explorer and entertainer into space, NASA ultimately decided that a teacher should be the first civilian in space. After the Teacher in Space program ended, a more defined education presence was outlined in the Astronaut Corps, when astronauts were allowed to interact more frequently with students and teachers. This resulted in students engaged in actual Space Shuttle and ISS missions through student experiments and payloads carried to space. The most recent NASA Educator Astronaut Program has Educator Mission Specialists who will carry out various projects while in space demonstrating such principles as microgravity and conducting student-designed experiments. Barbara Morgan will be the first Educator Mission Specialist. She was a teacher in Idaho and was originally Christa McAuliffe's backup in 1986. After returning to the classroom following the Challenger accident, Barbara was again invited by NASA in 1998 to train as an astronaut and now no longer works as a teacher. As a spacecraft communicator, she talks with the space station's crew to relay information between outpost residents and ground controllers. She is part of an ambitious program where three other Educator Astronauts were recently recruited from kindergarten to grade 12 teachers to act as Education Mission Specialists. Barbara Morgan passed the training process and has traded in her black board for a space suit as a payload specialist and full-time member of the astronaut corps.

Teachers and Space

There is a natural connection with each of us who look up at the night sky asking the most fundamental questions of life in the Universe. The goal of stimulating future generations can be found in the mission statements of the majority of space agencies. NASA wants to inspire the next generation of explorers. The Canadian Space Agency is committed to leading the development and application of space knowledge for the benefit of humanity. Japan's Aerospace Exploration Agency (JAXA) sees that space development is no longer a dream but a very important mission for economic growth, quality of life, security and the continuous progression of humankind.

Space science and technology is an ideal teaching vehicle because it is inherently multidisciplinary in nature. Therefore, every discipline is valuable, whether it is engineering, entertainment, ethics or economics. This allows students to find their niche in space because there is definitive value in whatever they may be passionate about that reaches beyond the earth. Space captures the imagination of youth and reveals medical secrets for the aged through research that ranges from studying osteoporosis in astronauts to manufacturing super pure protein. Space has a unique multigenerational appeal. The crew complements of the past and the International Space Station partners remind us of how multicultural space is as a medium. Space is another place where humans can live. A teacher's presence in the space program has

helped boost public interest and curiosity. As shown in the American example, Christa McAuliffe became an inspiration not only to the public but to the teaching profession as well. She felt that her exposure as the Teacher in Space spoke well of the teaching profession. People have a connection with teachers. "That's our new frontier out there," said Christa McAuliffe "and it's everybody's business to know about space" (Corrigan, 2000). Sean O'Keefe spoke of the new Education Mission Specialist program and of the "obligation, a sacred trust, to ensure there will be a next generation of explorers. This will be a case of really dedicating effort to professional educators, who will also be proficient, trained and competent to handle all the other important mission objectives of every astronaut."(Harwood, 2002) Teachers are uniquely qualified to convey the merits of space education as a teaching vehicle because of what their job entails. Teachers come from all walks of life, from all disciplines and have a direct influence on many people at some point in their life experience. They facilitate opportunity and reason to discover the world around you. NASA's media coordinator said about Christa McAuliffe, "We're not looking for Superman; we're looking for the person who can do the best job describing his or her experiences on the shuttle to the most people on Earth."(CMP, 2004) This affirms teaching as the ideal profession to meet the challenge of improving scientific literacy.

SES Business Plan

This proposal was designed to bridge the gap between education and public outreach activities by providing a person instead of a program. The Space Education Specialist is an education and public outreach initiative designed to perpetuate itself even after the initial pioneers are gone. The SES desires to make a consistent connection between the profession of teaching with its traditional clientele of young minds and the world of industry, science and technology using space as the vehicle of educational instruction. The SES seeks the support of local teacher federations, provincial ministries of education, the national space agency and an international governing body to achieve a unified approach to increasing scientific literacy in our youth and in the general population. SES intends to provide a long-term solution to helping the public understand why space science and technology matter to society and to the success of a nation. The SES will serve to identify, enhance and expand education and public outreach worldwide. Its primary goals are:

- To link existing curriculum to national space research and studies and generate new activities within existing curriculum that draw upon space science and technology as its source. Space as a teaching vehicle recognizes the need of all disciplines for future success. Space education can promote the skill sets needed for a future that encourages research, innovation and the development of new science and technology.

- To connect industry with earlier education so that children learn the benefits of science and technology from a very early age. To promote careers in this area because of the connections students make with real people in these areas of industry where they may one-day work.

- To intentionally invest in teachers as professionals. A teacher is a powerful resource in addition to a program. People inspire people much better than programs inspire people.

- To efficiently coordinate the use of local, provincial, national and international resources that allows teachers to receive the best professional development possible. To bring that professional development back to their colleagues, teacher training facilities and classrooms in a meaningful way that impacts students directly.

- To enhance and expand international collaboration in education and space–related projects.

- To lay the foundation for an increasingly more scientifically literate voting electorate that can influence the science and technology of our country for the betterment of our society

The SES program would use resources from those multiple areas that have a vested interest in promoting long-term educational goals. A SES would provide educational products, unique educational research opportunities, exceptional networking between the education and technology communities and use the engaging venue of space to accomplish its goals. In Canada, the following 5-year plan could be followed in partnership with these key associates:

1. The Local Board(s) of Education would provide release time for the SES the first year, hardware such as data projector, digital camera, web cam media kits and videoconferencing capabilities with accompanying software and in-service time. The teacher in return writes curriculum using existing Ministry documents and *Intentional Education* activities that span the curriculum from grades 6 to 9.

2. The Local Teacher Federation would provide release time the second year, and for specified times outside of the SES program for promotion. The teacher provides professional development presentations and workshops for colleagues and the promotion of science and technology education both provincially and nationally.

3. Provincial Teacher Federation would provide a yearly scholarship to the International Space University (ISU) for qualified teachers who apply directly and submit themselves to the selection process, as do candidates from other countries. ISU is a postgraduate educational institution that provides international training for space professionals using an interdisciplinary curriculum that is unique in the world. In return, the teacher provides curriculum units and inserts into provincial teacher resource publications. In-service workshops for student teachers would be coordinated with teacher training colleges.

4. The ISU provides SES networking, administration, and accountability for the selection of candidates, and scholarship contributions towards transportation for attendance to the Summer Session Program. There is the potential use of a Team Project (TP) in the Summer Session Program or Masters Programs with Education and Outreach as one of the TP drivers (ie. Space has a Face Astrobiology Design Project SSP02. (ISU, 2002) In return, the teacher provides promotion of the program to industry, academic institutions and professional conferences. Potential sponsors for team projects that have strong Education and Public Outreach drivers could be found among Ministries of Education.

5. The Space Agency or space industry partner would provide access to their facility, staff programs, and professional visits. The teacher provides public outreach proposals and possible implementation of selected programs by the Space Education Specialist.

6. Ministry of Education and the Canadian Space Agency would provide a scholarship to pay the cost of specified astronaut training. The teacher supplies the ongoing human resource that promotes science and technology in Canada with the goal of significantly increasing scientific literacy especially among the future electorate.

The SES program would follow a five-year time line (see Table 1). The successful teacher would be seconded for only two years from his/her board of education, and return to teach for one-year half time with mentoring and networking responsibilities for other teachers and boards. The first summer would be spent at the International Space University Summer Session Program (SSP) as an introduction to the SES plan. September to the end of June of the following year would be spent with a Space Agency or Industry partner learning about that particular agency and developing outreach materials for them. The SES would continue to network with ISU contacts to develop other *intentional education* activities to be used in school systems based on what is learned from the agency or industry partner. Networking with educators would secure actual classrooms for live web camera video conferencing. The Space Education Specialist would take the subsequent summer off. From September to the end of June in year two he/she would

attend astronaut-training sessions with Canadian astronauts. Selected activities such as neutral buoyancy, extreme weather survival, life sciences experiments, and launch support would be primarily in Houston at NASA or California at the Jet Propulsion Lab for unmanned space flight. The final summer would allow preparation for reentry into the school system. As a half time teacher the SES would do workshops for other teachers and presentations for schools and public venues as an Educator Astronaut where activities are provided via live web camera video conferencing. Year 4 would have the SES teacher returning to the classroom with selected release times for the promotion of the program and selected outreach venues. Year 5 would allow networking with the other SES teacher who has started the program to "pass the baton" and provide transition for the next Space Education Specialist.

Table 1 SES 5 year timeline includes 2 years out of the regular classroom

Year 1	Year 2	Year 3	Year 4	Year 5
Summer spent at ISU SSP program, introduction to space agency or industry training (continues into year 2)	Full time at space agency or industry training, developing resources, networking and securing classroom contacts (continues into year 3)	Training with Canadian Astronauts for selected activities, video conference with schools (continues into year 4)	Return to half time classroom/ half time teacher professional development with release time provided for SES promotion	Return full time to classroom and network with 2nd SES teacher who has started the progrram at year 1 to facilitate transition

Intentional Education

An Overview

What tools can a teacher use in promoting space science as a teaching vehicle? Other than defining public outreach, education and the SES, it is also the goal of this paper to outline, in a practical way, activities that span grades 6 to 9 referred to as "*intentional education*." The concept of *intentional education* was designed to use a space theme during these influential years with complementary activities that are reinforced annually. These activities, with a common theme that is revisited each year, are used for ages 11 to 14 to produce a varying design challenge in a specific space related context such as return to the Moon. The term "intentional" is used because we purposely promote a concept over four years allowing the student to explore the same theme more deeply every year. Each year they attack the problem from a different angle with a different emphasis but within the same design challenge. These activities can build on each other but are also able to stand on their own without a great deal of previous knowledge. This means that a student is still able to do the activity in grade 9 without having ever participated in the grade 6, 7 or 8 events. However, it is the goal of "*intentional education"* to inculcate a strong interest in space science and technology such that students have room to grow over the four years as they participate in the design challenges. Using the title, "Kids Need Space" an "*intentional education"* unit could be planned for the Ontario Science and Technology curriculum for ages 11 to 14 which may include the following activities:

Grade 6

- Space science unit uses the study of the moon as a celestial body to understand patterns of change, movement, eclipses, phases, tides and physical characteristics of the solar system
- Study origins of the Moon, literature about the Moon and colloquial sayings 'once in a blue moon, the man in the moon, lunatic etc…
- Challenge to use space architecture to design a lunar shelter using inflatables and lunar regolith within the context of actual moon geography such as craters, maria, rills, lava tubes etc…

Grade 7

- Interactions within ecosystems and Earth's crust unit uses the study of how humans and plants might survive in a hostile environment such as the Moon
- Explore the needs of living things in a lunar ecosystem compared to that of the earth or a space suit as a closed ecosystem that provides everything needed for life for a short period of time
- Design a method of agriculture on the Moon that would allow long-term survival using the Tomatosphere program
- Using the characteristics of living things challenge students to design a long term lunar home with such sub systems as mission purpose, crew selection and size, science and off-nominal situations; compare this to ISS sub systems
- Introduce the concept of mining on the Moon compared to that of the Earth; study rock types and formation

Grade 8

- Mechanical Efficiency unit investigates how machines and robots could help humans explore the Moon in $1/6^{th}$ microgravity
- Lego Robotics challenge, construct a lunar lander, lunar rover and use hydraulics and pneumatics to make robotic arms to efficiently mine the lunar surface, look for water and assist humans in working on the surface of the Moon with consideration of higher levels of radiation and temperature extremes.

Grade 9

- In its Earth and Space Science unit called "The Study of the Universe" the Ontario Ministry Guidelines lay out far-reaching concepts, skills and applications. (MET, 1999) (i.e. analyze and predict the time required for a spacecraft to travel to the Moon and investigate the factors which limit the feasibility of the voyage such as fuel, costs, time, and human requirements
-Relate the beliefs of various cultures concerning celestial objects to aspects of their civilization (i.e. aboriginal beliefs, Greek mythology)
- Challenge students to plan ways to model and/or simulate an answer to questions chosen (i.e. How can humans return to the Moon? What are the spacecraft requirements? What potential is there for tourism?
- Students design an experiment to be tested to study crater impact, parachute probes for payload landing and microgravity research with drop towers or games in $1/6^{th}$ microgravity
- Students attend the Center for Research in Earth and Space Technology (CRESTech) Innovation network conference that exposes students to space technology in an industrial/working setting.
- Challenge students with space related current events such as planetary protection, space junk and its impact on society.
- Challenge students with the colonizing and commercializing of the Moon for the good of humanity with a long-term lunar base.

Potential topics for *intentional education* might include microgravity research, living and working in space, the sun and its effects on the Earth and its atmosphere, studying satellites with communication and information technology, space and society related to science and technology careers, robotics and Missions to Mars. Using a diversity of space themes, each year would address the same problem but from a different emphasis commencing with concept investigation, followed by measuring, then simple and more complex experimentation.

Measuring the Success of SES

Any program that seeks to educate should be evaluated for success and assessed for progress. Any tools that are used must be administered with the goal of acquiring summative results that allow the program

and its people to build on experiences and constructive feedback. The SES program needs to model sound evaluation and assessment of itself. Therefore, the Space Education Specialist program could utilize such measuring tools as Trends in International Mathematics and Science Study or TIMSS. (TIMMS, 2004) As a comprehensive and rigorous assessment tool, TIMMS could be used to provide feedback on whether or not the SES program was achieving its goals towards greater scientific literacy. Using such a measuring tool would provide invaluable feedback for the success of this education program. Administered in 1995, 1999 and 2003, TIMSS provides trend data on students' mathematics and science achievement from an international perspective. Other countries seeking to establish similar education based programs would be invited to participate in the TIMSS evaluation. Thus a base line of success could be monitored and thereby establish indicators of the long-term success of such initiatives.

FUTURE CONSIDERATIONS

Any good teacher leaves students with more questions than answers. Questions are the force that drives the quest for the future - not knowing all the answers. The Space Education Specialist is an attempt to put a fundamental profession in the best possible position to help society ask the questions that encourage wise decisions in the future. These would be from an international, intercultural and interdisciplinary perspective that respects what humans can be and should be in the universe. With this in mind the following are future short-term considerations with regard to the SES:

1. Present a plan for what individuals can start to do now to propose a similar strategy for other education systems.
2. Add an education section to the International Space University that has ministries of Education sending their teachers for the Summer Session Program. Part of their team project includes the designing of specific curriculum activities for their countries in the context of the SSP team projects. Investigate a potential Masters in Space Education or MSE at ISU.
3. Explain to potential SES partners why there should be an investment in a teacher as a Space Education Specialist.
4. Outline the mutual benefits for industry's part in education.
5. Define what a teacher will actually do as a Space Education Specialist. How will he/she be part of the Astronaut corps?
6. Conduct more research on what long-term space based education would look like and how it could be measured quantitatively and qualitatively for success.

Long-term educational investments with regard to space, science and technology will always have a greater public value than short term outreach efforts. Where we ***catch*** the public is where we will ***keep*** them.

CONCLUSION

If you are planning for a year, sow rice; if you are planning for a decade, plant trees; if you are planning for a lifetime, educate people. --Chinese proverb.

Public outreach is like planting rice. It can effectively meet a short-term need but it has to be replanted every year. The public forgets or finds something else that "tastes better" for the moment. By its very nature, education has an intrinsic ability to perpetuate itself if the educators have an intentional plan. In the hands of an educator, space can be a very powerful vehicle for the study of science and technology. The Space Education Specialist is an attempt to initiate a long-term investment in the education of our children using space as the medium of instruction.

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