A NOVEL APPROACH TO HANDS-ON SPACE EDUCATION OUTREACH FOR SECONDARY SCHOOL STUDENTS

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ABSTRACT

The Swedish Space Corporation (SSC) flies weather balloons from Esrange, Sweden on a daily basis. Extra flights are available to schools for an accessible fee, allowing schools to have hands-on space education projects for their students. Such projects can then include flying hardware in near-space.

In a joint effort, Sint-Pieterscollege Jette (SPJ) from Brussels and Stedelijke Humaniora Dilsen (SHD), two secondary schools, flew such a balloon mission in April 2010 carrying out a variety of experiments designed, built and tested by students.

1. HANDS-ON PROJECTS

A plethora of space-related research fields make space education an especially rich field for scientifically inclined youngsters: dynamics, atmospheric physics, climatology, geology, biology, radiation and nuclear physics, astronomy and astrophysics to name but a few.

Unfortunately theoretical knowledge, while interesting, falls short of teaching our teenagers what it is like to work in the scientific or technological sectors. It is therefore the opinion of the authors that secondary schools students should be given the chance, whenever possible, to complement their theoretical studies with practical experience.

Ideally, such practical experience should cover all aspects of a genuine 'professional' science project, starting with the research question, and going through all intermediate steps, up to the development and testing of hardware, ending with data processing, interpreting the results and drawing conclusions.

Given the relative lack of maturity of the students, teachers should be prepared to provide additional support in certain fields, should a particular group of students have specific needs. Project management for example, is one aspect secondary school students are rarely familiar with, even if talent in that field is rapidly developing at the age of 17 or thereabouts.

2. THE PRIMARY EXPERIMENT

The mission, including a trip to Esrange to prepare the payload and witness the flight, was crafted around a sound spectrum experiment, for which both schools built and tested subsystems. This approach proved to be a very interesting exercise holding much promise for the future. Good and extensive communication on system requirements and properties was essential as both hard- and software needed integration for the whole setup to provide useful data. The goal of the experiment was to determine if there were any frequency dependencies in sound extinction as air density decreased during the balloon’s ascent.

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Therefore, a sound spectrum ranging from 100 to 10000Hz with 100Hz increments was produced and recorded at 30 second intervals throughout the balloon flight.

SHD would provide a microcontroller equipped with a piezo-speaker, a thermosensor and a digital timer. The software in the microcontroller would ensure registration of time and temperature throughout the flight. SPJ would provide an identical microcontroller with a microphone circuit and an external EEPROM for recording the sound spectrum data.

While the hardware-circuitry development was split in two parts, both circuits would eventually be integrated on a single PCB, after each group had developed and tested their own hard- and software, and after integration tests had been performed.

The hardest part proved to be software integration though, as it was unclear how long it would take to process a single measurement (microphone reading, AD-conversion and writing to EEPROM). Since our schools lacked the equipment required to figure this out, it was decided we would software-protect the experiment, having both microcontrollers giving each other the go-ahead whenever appropriate. This got the teachers involved more heavily than desirable.

3. OTHER EXPERIMENTS

Since the balloon was to have a payload capacity of about 1kg, and the sound spectrum experiment was likely to come in at less than 300grams, it was decided to let both schools add experiments to the flight.

Among these were a digital camera, plant seeds, eggs of *Artemia salina* and *Daphnia magna*, as well as a 3D-magnetometer, a thermometer and a pressure sensor. The latter two experiments were both located inside the gondola to determine conditions there.

![Figure 3. 3D-magnetometer made up of 2 perpendicular 2D modules (bottom). Three 12-bit ADC’s (numbers 1 to 3) convert the analog signals. Data are stored in external EEPROM (left above ADC number 3).](image)

The biology samples were fixed on an outer panel of the gondola and contained in punctured canisters, in order to expose them to outside conditions.

4. TRAVEL TO ESRANGE

Having the students design and develop the required hard- and software was labor-intensive and time-consuming. It was deemed useful though, also to make the students part of the fundraising effort, making it clear to them that very practical obstacles can rise that impair a good idea's realisation.

Money had to be found to buy components and build hardware, but also to cover travel expenses and lodging at Esrange.

Several brain-storming session among the students were organized to generate ideas for fundraising activities. Letters were written to companies in the sectors of aerospace and technology, and to local and not-so-local authorities. A cake sale was organised and appropriately named after Sint-Pieterscollege's space education project: SP. Ace. The gimmick proved hugely successful and several hundred 'space-cakes' were sold. Profits were high enough to pay for the balloon.
5. EJAFJALLAJÖKULL

As air traffic was seriously disturbed in Northern Europe at the time of our visit to Esrange, the balloon flight was postponed until after our departure.

The fully prepared gondola was handed over to SSC personnel and flown a few days later. The flight and recovery were successful, and the payload was sent to Brussels for data retrieval and analysis.

Getting back to Belgium turned into a 3-day adventure with 14 hours of train to get to Stockholm, followed by a day of chaos, then a 20 hour bus trip to Belgium.

Future 'expeditions' of a similar nature need to take into account the possibility of a launch delay, or accept shipping of the payload after recovery. This may limit the range of possible biology experiments.

6. EXPERIMENT RESULTS

It took the students involved the better part of a year to design, develop, test and fly their experiments. The gondola arrived in Brussels by late May and there was not enough time for the students to thoroughly process the data from their own experiment before the start of their final exams.

![Sound spectrum graph](image)

*Figure 6. First sound spectra taken on the ground, showing small and larger peaks. Interpreting these peaks is an ongoing effort for the students.*

Therefore a new generation of students was entrusted with the task of analysing and interpreting the results [1]. Several surprises have occurred in this data processing project. These results are treated in another paper.

7. EVALUATION

On the positive side, cooperating with another school on such a project brings out the best in each team, as no-one wishes to let the others down or to lose face.

For the teachers, it reduces the burden of having to go through every aspect of the project alone. Indeed, such a project is far more than developing an electronic circuit. The science behind balloon flights, atmospheric physics (relevant to problems of overheating or undercooling) and more needs to be addressed. Travel arrangements have to be made. Fundraising has to be organized, etc. Having two teachers manage the project makes it all easier to tackle, especially when things don't go as planned (as on the return leg of our voyage).

A drag on these projects is that both partners may not be at a similar level of proficiency technologically, making contributions to a joint experiment harder to integrate. Organizing the flight and trip together but letting each school fly its own experiment or set of experiments may be a better approach [2].
8. CONCLUSIONS

There is great need in Europe for hands-on space education projects, giving secondary school students the opportunity to gain practical experience and actually fly a science experiment to the edge of space.

Such flight opportunities open the door to an enormous variety of learning opportunities for youngsters that are scientifically or technologically inclined, and should therefore be made available on a regular basis.

Schools cooperating on integrated experiments where several parties bring in part of the hardware makes the project harder to manage, while project management relies more heavily on teacher involvement.

Also, the parties concerned should have comparable technological know-how to make the cooperation challenging for all involved.

Even so, there is great benefit from cooperating this way. Regular and extensive communication is a prerequisite and enhances understanding of the subjects tackled. Also, to contemplate different approaches of a particular problems is beneficial to both the project itself and the students involved.

9. ACKNOWLEDGEMENTS

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References
