

Accessible and Flexible Delivery Methods in Experiential Space Education

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Abstract

To date, AlbertaSat's educational outreach team has shared our passion for space with over 6500 students across Western Canada through curriculum-based lessons and hands-on activities. The COVID-19 pandemic has created a need to adapt the way educational activities are conducted and has shown just how important accessibility and flexibility is when it comes to education. We accepted the challenge to adapt our lessons with regards to delivery methods. Our teaching philosophy underwent a thorough process of iteration, improvement, and development for in-person, hybrid, and remote learning. In the process of revitalizing our lessons, we also focused on relating curriculum outcomes to the real world. We introduce students from kindergarten to grade nine to a selection of different space science roles. Our sessions range from satellite design to software and electronics development to Computer Aided Design (CAD). For high-school classrooms, we work with teachers to create individualized lessons for their students' skills and interests. Our efforts bring the cutting edge into the classroom and show students that careers in aerospace are within their reach.

1. Introduction

AlbertaSat is a group based out of the University of Alberta consisting of post-secondary students and faculty whose motivation is to develop, launch with the help of the Canadian Space Agency, and operate cube satellites. The team has made two satellites, known as the Experimental Albertan #1 and the Experimental Albertan #2, or Ex-Alta 1 and Ex-Alta 2. Ex-Alta 1 [1] was the first satellite project, launched in 2017 as part of the NanoRacks-QB50 mission [2] which used the International Space Station to deploy a constellation of 28 CubeSats to study the upper reaches of the Earth's atmosphere over a period of 1 to 2 years. AlbertaSat contributed Ex-Alta 1 to this international collaboration involving academia and research institutes from 23 different countries. It studied space weather through the observation of plasma flow and its interaction with Earth's magnetosphere and lower ionosphere, this phenomenon is known colloquially as the northern lights. Ex-Alta 1's mission came to an end in 2018 during the satellite's re-entry into the earth's

atmosphere. Subsequently, AlbertaSat has been working on Ex-Alta 2, set for launch in January 2023 with the mission objective being to predict, track, and assess the effects of wildfires on our landscapes, as well as to monitor active flame fronts, with an in-house built multispectral imager which captures near-infrared and infrared light.

Building off the innovative experiences of the technical teams, the educational outreach team has been able to develop initiatives for students from kindergarten to grade 12 across Western Canada. Through classroom sessions and participation in events we teach students experiential skills directly related to space exploration and development. This paper will demonstrate the accomplishments of AlbertaSat's educational outreach program and the importance of accessible and flexible delivery methods for teaching experiential space education.

2. Literature Review

Everything elaborated in this paper is original qualitative primary research. To create truly meaningful learning experiences, we applied several educational theories to our developed content (lesson plans, activities, presentations decks). Constructivism is an educational philosophy which centers around learners [3] and dictates that they learn best when they are active learners [4] who acquire and demonstrate their own knowledge. Within this ideology applied learning is used to bring practical or career-oriented experience into the classroom [4]. Experiential learning takes it one step further by showing the purpose of an activity, having students reflect and then reapply their knowledge [4]. These educational principles are the cornerstone of our program. As we developed the new sessions and adapted them for virtual learning, our main objective was to provide kids with the opportunity to apply concepts they'd already covered in class in a real-world space-science scenario.

3. Educational Outreach: Fundamental Pillar of the Organization

The overarching goal at AlbertaSat is the promotion of an open and accessible space sector.

The team utilizes completely open-source philosophies— even extending to the educational outreach program. Since the inception of AlbertaSat, educational outreach has been a core pillar. Knowledge is pulled from our technical subteams to create out-of-this-world learning opportunities that we bring to students across Western Canada (and hopefully one day the world). We hope to inspire and engage students with applied learning [3] in the fields of science, technology, engineering, and math. Our goal is to make space science engaging and accessible, and even inspire young students to see a future in the space workforce one day. We have a selection of activities and lessons designed for each grade level, which combine to form a comprehensive storyline from our solar system and space science to satellite design, to industry standard skills and competencies. Each session involves an activity pertaining to the Alberta math or science curriculum outcomes [5], [6], [7], [8], bringing hands-on learning to the classroom. This allows us to teach a concept and then have the students retain it by using their creativity to complete a practical activity related to the subject. Through each opportunity, the educational outreach team is able to share AlbertaSat's experiences with schools and other youth-facing groups and have the students reflect and apply the same concepts to their own project or activity [9]. AlbertaSat's Educational outreach sessions began in 2014 [10] and to date, the team has worked on collaborations with schools and programs across Western Canada, reaching more than 6500 students.

4. Transition to Remote and Flexible Learning

The world has undergone unprecedented shifts to remote work and learning due to the COVID-19 pandemic [11]. This shift posed great barriers to traditional education methods. The changing nature of public health guidelines created an atmosphere which made it impossible for us to participate in classrooms the same way. Historically our outreach focused on in-person lessons where our members interacted casually with students, aiding them through a design challenge. This avenue was no longer available and Canadian students were being moved between remote, in person, and hybrid classroom set-ups with very little notice. A critical examination concerning the program's delivery methods was required for opportunities to continue for students, as the world moved towards an unknown future.

4.1. Where we came from

Before early 2020, the sessions involved limited to no use of the technological tools available, such as computer slide decks and other computer-based

programs. Students were briefed on the desired result and verbally provided with the knowledge and instructions to carry out procedures to achieve said result. The main goal with each session was to ensure engagement of the students, and although moderately tied to curriculum outcomes, the focus was on sharing the experiences of AlbertaSat with the students [10].

4.2. Hurdles from the pandemic

The move to online education created obstacles that restricted the ability to present sessions with schools since our traditional method of delivery could no longer be utilized. Our session structure did not have the built-in flexibility to manage these situations. New classroom hurdles came to fruition [11], for instance:

- External visitors no longer permitted
- Group work no longer permitted or heavily limited
- Material isolation for up to 72 hours between uses
- In some cases, complete remote learning with no possibility of material delivery

To maneuver these boundaries, each session underwent a reviewal and breakdown process to be adapted for accessible and flexible learning. Changes were made to provide possibilities of numerous delivery methods, which include remote, hybrid and in person options. This was especially important during periods of 2021 and early 2022. For remote sessions, activities that required physical interaction with tools were changed to use computer-based programs that still allowed students to develop skills that related to the activity. These changes enabled us to provide aerospace education based on topics relevant to the team to a wide range of grades. Since the use of technology was increasing for students of all ages and different experiences, the sessions were developed with accessible technology no matter the grade level.

4.3. Adapting material

The first change we made was to design a specific session for each grade. In person it is easier to adapt concepts on the fly. When using pre-made slide decks it is not possible to change the difficulty of the lesson dynamically. Narrowing the target age range for each session gave the opportunity to add several interesting topics to our roster of sessions. Table 1 shows the full educational outreach curriculum.

Comprehensive slide decks had to be made so that technical AlbertaSat members could present them to a classroom of students with little preparation while maintaining consistency in the quality of delivery. To facilitate this, we created lesson plans and speaker notes for each session. With the creation of this material, we are now able to present to classrooms

Table 1. A comprehensive list of AlbertaSat's educational outreach sessions, educational objective, and interactive activity [9]

Session Name	Lesson	Students Will...	Available For:
Northern Lights	Learn about the causes of the northern lights (solar flares and their effects on Earth's magnetic fields), and about Ex-Altia 1, our satellite which studied these properties.	... Draw the northern lights with watercolor pencils.	K, 1, 2, 3
Our Solar System	Learn about all the planets in our solar system and about the satellites we have built.	... Construct a planetary mobile using modelling clay, string, and sticks.	K, 1, 2, 3
CubeSat Blueprint	Learn about all the essential components of a cube satellite.	... Design their own satellite with a unique payload and draw it on Engineering paper. They will then be able to pitch their design to our members who will be role-playing as a Canadian Space Agency Funding committee.	K, 1, 2, 3, 4
Icarus: Building and Testing	Learn about our cube satellite structure which was designed and built in-house and named Icarus after the Greek God who flew too close to the sun.	... Work in small teams to build their own cube satellite structure using given materials and then stress test the frame, mimicking the process our own student team uses.	3, 4, 5, 6
CubeSat Structure	Learn about all the essential components of a cube satellite.	... Fold and glue a 2D shape into a rectangular prism, then use a variety of materials to construct their model. They will then be able to pitch their design to our members who will be role-playing as a Canadian Space Agency Funding committee.	4, 5, 6
Satellite Electronics	Learn about the basics of an electrical circuit and get introduced to all the electronics inside our cube satellites.	... Create a work of art using markers and pencil crayons which incorporates an LED. The backside of their page will have a working circuit deposited using glue and foil to act as a pseudo-PCB.	4, 5, 6, 7

Wildfire Imaging	Learn about our second satellite, Ex-Alta 2, which will be taking images of the Earth to be used for wildfire sciences. Students will learn about many wildfire properties and how they affect society.	... Perform an analysis as "wildfire scientists" on hypothetical compiled data from our second satellite, Ex-Alta 2.	4, 5, 6, 7
Scratch Coding	Learn the basics of logic statements and coding as well as their applications within our satellite.	... Create a playable asteroid game using the Scratch coding language.	5, 6, 7, 8
Drafting a CubeSat	Learn about all the technical subsystems within our satellites.	... Design a cube satellite to scale using drafting techniques with views of all the sides and the inside.	7, 8, 9, 10
3D modelling with AlbertaSat	Learn about the applications that 3D modelling has for space scientists and engineers.	... Create a model rocket design using the TinkerCAD program.	8, 9, 10
Solar Energy	Learn how satellites create power, and how to prototype electronic circuits.	... Using a breadboard, create several solar circuits with increasing complexity.	7, 8, 9, 10
Individualized Sessions	For grades 10-12 we are happy to work with you to cater sessions specifically for your needs.	In the past we have taught programming in C and Python, 3D modelling in SolidWorks, wildfire sciences and optics, and provided in-depth lessons about our satellites' subsystems.	10, 11, 12

in person, in a completely remote situation via Google Meet or Zoom, or even by having us join remotely (projected onto the screen) with students in person. The additional material created for our presenters allowed them to walk in with very little preparation and deliver a consistently high-quality session. After the slides were created, an evaluation was performed to determine how each session could be adapted to have remote activity options. For example, we have a lesson where students assemble a paper puzzle and do an analysis on the final image. With a bit of creativity, we realized that the puzzle could be scanned and used in Google Jamboard for kids to assemble online without the need for a physical kit. This allowed us to offer sessions to students anywhere, alongside students in a classroom with a physical kit, at the same time.

In each situation where it was impossible to use physical kits there were additional hurdles from the COVID-19 pandemic. As students could not work in groups in most situations, and material could not be passed directly from one class to another because of

the need to isolate material [12], we had to build many more kits than before. Visiting three classes of 30 in a day used to mean we could bring 15 kits and have students share as well as reuse between classes. Now an event of that size would require 90 kits. On our end this meant we had to be incredibly organized ordering parts and building kits at a much larger scale. Supply chain issues affected us as well and we often had to be flexible and creative to make kits with whatever materials we had available.

4.4. Redesigned lessons

Using iterative development, the team has been able to create and improve multidisciplinary sessions which focus on space science and aerospace learning. These sessions are divided into 4 topics: an introduction to space for junior elementary classes; cube satellite design for elementary classes; science and engineering for middle school, and individualized high school sessions catered to the needs of individual teachers. Each session is organized and developed to

target curriculum outcomes for a specific grade but are adapted to be taught successfully to a small range.

Primary students are exposed to an introduction of space at levels of kindergarten and grade 1. The activities focus primarily on the use of fine motor skills and the application of art and building. Students are able to explore the different aspects of the space environment, including the causes of the northern lights and their effects on Earth's magnetic fields, which is directly related to the mission objectives of Ex-Altia 1, as well as the solar system as a whole.

The second topic of cube satellite design is inspired by the work of AlbertaSat's technical teams. These sessions focus on applicable skills for design

using concepts found in the science [6] and math [8] curriculums. The concepts covered under satellite design include general satellite and cube satellite design, printed circuit board (PCB) design, and cube satellite structure design. Students continue to work on the ability to construct with purpose, while learning and applying essential concepts in science and engineering. These lessons also provide students with the opportunities to consider design constraints during construction. We encourage students at these ages to pitch and share their ideas and designs with the group at the end of the sessions. Figure 1 shows an image of our solar electronics prototyping lesson.

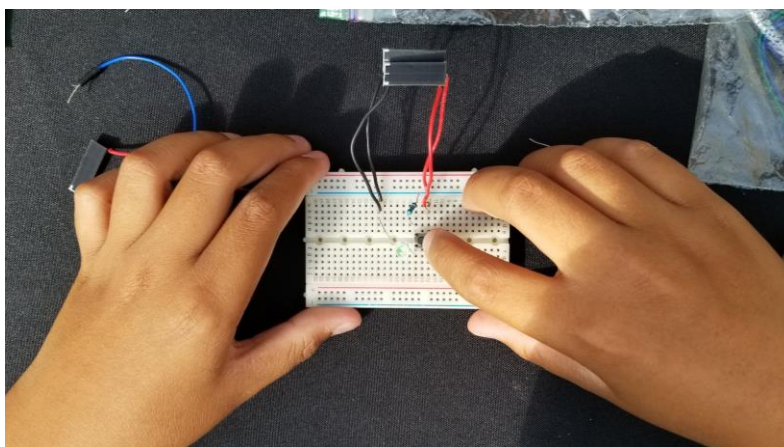


Figure 1. The finished product of our solar electronics prototyping lesson

Lastly, with our oldest groups of students we share skills and competencies required to work in the space industry (and many other technology industries). Sessions include:

- The investigation of logic statements and coding, and the relation to real-world applications.
- Scale drafting and 3D modeling.
- Prototyping electronic solar circuits.
- Data analysis of wildfires, based on the main mission objective of Ex-Altia 2.

Students work primarily on experiential skills of observation and identification of patterns and problems, as well as mathematical analysis. This means that in addition to learning curriculum knowledge [5], [8] they also develop practical skills that may be useful in their future education or careers.

For high school groups we have found that making curriculum-based sessions is not as impactful because it limits the number of teachers who can host us in their classrooms due to the subject-based split of classes. Instead, we design activities for a specific

classroom or group based on the teacher and students' particular interests, vision, and skill level. Sessions are created by request and may be centered around programming, subsystem design, computer aided design, and optics, among many other things. These sessions follow AlbertaSat's technical experiences closely in order to have the highest level of experiential learning. The ability to curate individualized sessions allows flexible learning, with students being exposed to beneficial and challenging sessions on a case-by-case basis depending on their knowledge and skills.

5. Results

Over the last year AlbertaSat has presented sessions in over 80 classrooms and organizations across Alberta and Northern Canada, a reach only attainable by the development of the flexible delivery methods. Pre-pandemic, the highest numbers of students ever reached was attained in 2018, with well over 1000 students participating in our sessions. After adaptations of the curriculum, the team reached 880 students in 2021 which surpassed pre-pandemic outreach numbers from 2019. To date this year, we have shared our passion for space with over 2000

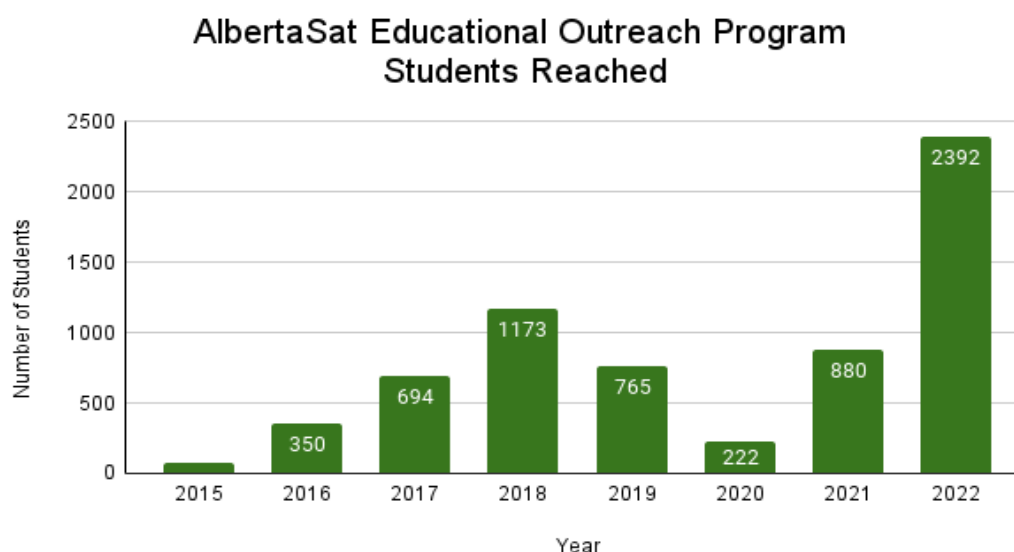


Figure 2. The number of students AlbertaSat's education outreach program has reached over the years [9]

students [9]. Figure 2 shows our yearly outreach since inception.

5.1. Training our workforce

What truly sets our program apart is the direct mentorship the students receive from AlbertaSat's technical team members. Students can ask questions to those who have actually designed, built, and held a satellite, we have the knowledge and stories required to engage with students and answer their questions. However, our technical members do not necessarily have any educational background or experience with teaching. With in-person teaching it is easy to adapt presentation skills to engage students, you can easily see the engagement of the classroom. The shift to online learning posed a large challenge to our technical members who needed to learn our new material, and new flexible styles quickly. Last fall we piloted an internal training session for in person delivery and for online delivery where we highlighted key strategies for success when teaching our sessions. We had to show our members not only how to teach students, but how to navigate our new plethora of internal resources (speaker notes, varied forms of activity kits, lesson plans, etc.), and shared tips and tricks to keep students engaged while participating remotely.

6. Conclusion

Since the inception of AlbertaSat's educational outreach team in 2014, our growing passion for space has been shared across Western Canada. Over the years, AlbertaSat's educational outreach team has

developed and improved the services offered to classrooms. Through creative improvements and careful deliberation, a comprehensive space science curriculum which bolsters Alberta curriculum outcomes has been created. Our program has become more flexible and therefore can be used to reach a wider range of students. We are no longer limited by driving distance. In 2018 we had well over 1100 students participating in our sessions. After revamping our curriculum after the pandemic hit, we reached 880 students in 2021. This year to date (January-October 2022) we have reached over 2300 students, and well surpassing our pre-pandemic outreach numbers from 2018 [9]. We help students dive into space science and engineering earlier on into their academic careers and adopt skills prevalent in the field. With this program we hope to inspire the next generation of students and show them that aerospace science is within their reach.

7. References

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