The Future of Education Is Founded on AI, 3D Printing and NewSpace Tech – ENGINEERING.com

There are currently over 100 million students waiting to become the next generation of engineers, rocket scientists and astrophysicists to get humans from Earth to Mars and beyond, but they may not be able to fulfill their potential simply due to a lack of access to a quality education. According to a study from UNESCO, more than 100 million young people worldwide, 62 to 66 million of whom are girls, are not attending school of any kind. Hundreds of millions more are unable to afford good-quality or safe schools.

However, groups like OneWeb and ONE are aiming to provide universal Internet access worldwide by 2020, greatly expanding the ability to use educational resources online. Nevertheless, Internet access does not guarantee a quality education.To address this problem, imagine if there was a massive, free online academy where any student or teacher with broadband could learn science, technology, engineering, art and math (STEAM) from educators around the globe, as well as the greatest minds in their fields, including NASA scientists, cutting-edge researchers and NewSpace engineers? On top of that, what if they had an artificially intelligent tutor and mentor to guide them in their learning? That's what Enterprise In Space (EIS) is trying to achieve, and it all begins with one giant class science project: the design, launch and recovery of a 3D-printed spacecraft that will orbit Earth with 100+ active and passive student experiments and a link to an AI to help the students run them and analyze their data.

To pull it off, EIS, a nonprofit program of the National Space Society, has drawn up the plans, put together an expert team of space veterans, raised $27.5 million in in-kind donations and partnered with some of the biggest names in the NewSpace industry. Now, all it needs is $32 million to put the plan in motion and set a course for the stars.**NewSpace Education**

To engage students in STEAM education and space exploration, EIS is hosting contests and enlisting students from all grade levels—kindergarten all the way through postgraduate education—to design experiments to be flown aboard a 3D-printed orbiter dubbed the NSS Enterprise. From now until the spacecraft is launched in 2019 or 2020, the winning experiments will be used as the basis for online curricula and lesson plans to populate EIS' massive open online course platform, known as the EIS Academy.

Once launched, the NSS Enterprise will orbit our planet for up to one month, carrying not only the experiments, but also Ali, an advanced artificial intelligence that will manage the active experiments. Ali will also serve as the voice of the spacecraft, allowing student teams on Earth to engage with the AI platform using natural language. In fact, Ali will eventually act as a personal tutor to students from around the world.

The EIS Academy will be overseen by EIS Education Manager Lynne F. Zielinski, one of the most decorated space educators in the world, who has mentored students to fly experiments in space for the past 26 years. In speaking with ENGINEERING.com, Zielinski said that the program will not only give students the tools to become engineers, but EIS will train teachers as well. "The whole wrap around here is two-fold: engineering the over 100 student experiments to be sent into space and to tap into the processes necessary to create STEAM learners," Zielinski explained. "To do that, teachers need training so they can excite the students. A lot of teachers are not necessarily science, technology, engineering or math teachers, and these

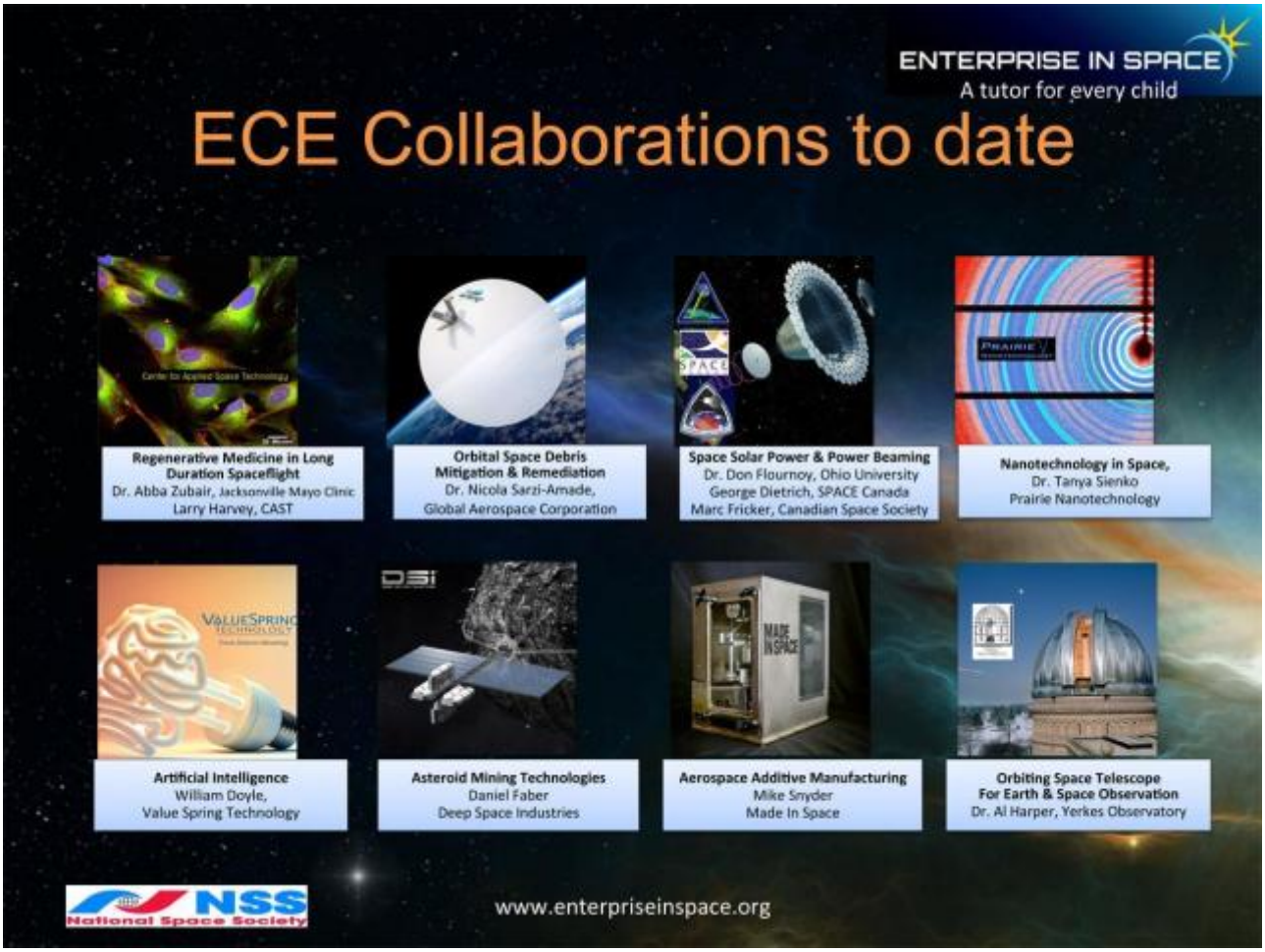
teachers tend to feel intimidated or shy away from teaching in these disciplines, like art, history or elementary school teachers. They really don't have an engineering background, so two of the things we want to do is show them that what they teach relates to the technical fields and give them some of the basic engineering knowledge needed to help their students design experiments to fly in space. In short, we want to give them confidence!"

She continued, "When we show them how easy it is—and it really is very easy if our engineering is done right—they feel confident enough to teach their students how to design their experiments. That's the key and one of the things that makes us so different from other programs. When they're concentrating on STEM and not STEAM, they're only focusing on things that are scientifically significant or interesting. We're not. We're saying it can be very, very simple. It can include some artwork, some music, anything. We encourage people to be bold and step out of the perceived norm and their comfort zone."

Higher Level Education The EIS Academy will serve not only elementary, middle and high school learners, but also university, doctorate and postdoctoral students as well. EIS will host competitions seeking experiments dedicated to advancing the state of the art in 10 areas. The contest teams will utilize and submit proposals within the Enterprise Centers for Excellence (ECE), where expert researchers and cutting-edge businesses will curate an extensive database of knowledge related to exciting topics such as space-based additive manufacturing, space-based solar power, stem cell research and more.

Zielinski explained that the additive manufacturing, space solar power and orbital space debris mitigation and remediation ECEs are already well developed. Two competitions are nearly ready to launch and will see students at the university and postdoc level participating with established NewSpace businesses to pursue some very challenging scientific concepts.

In the case of the space solar power ECE, hosted in partnership with Ohio University, SPACE Canada and the Canadian Space Society, the winning team will actually send an experiment aboard the NSS Enterprise that will test the ability to generate solar power in space, such as collecting sunlight aboard the spacecraft and delivering power wirelessly to a freeflyer for its mission orbiting Earth.



In the case of the orbital space debris mitigation and remediation ECE, the team will work with Nicola Sarzi-Amadè and Global Aerospace Corporation to utilize the company's Gossamer Orbit Lowering Device to deorbit debris in space.

Zielinski described an ECE as "a place where a wide variety of groups of people with the same interest and different disciplines can all come together and work together on that topic with the best information that we can get our hands on." Features of the ECEs include:

- A resource area populated with numerous papers that have all been vetted as the best resources associated with a given topic
- A cyber library ("Cybrary")
- An online journal that publishes juried and approved research and student papers
- An ephemeral board in which cross-curriculum visitors can present ideas related to the topic
- A question-and-answer area with access to STEAM mentor

Ali the Artificial Intelligence

While students will be able to monitor the progress of their experiments aboard the NSS Enterprise, the complete EIS Academy will be made open to the public, with students and teachers anywhere able to rely on Ali as a personal tutor and mentor.

In many school systems around the world, students have new teachers with every grade level. In turn, the knowledge, interests and learning style of a student will have to be picked up by new teachers year after year. Teaching coursework for different student learning styles is difficult. Ali, however, will be able to accompany

every student as they grow and act as a tool for teachers to address the needs of their classroom more quickly.

At the same time, students will also be able to access Ali on their own time. That way, any topic that isn't addressed in class can be addressed by the AI. Additionally, Ali can direct the student to a teacher in the EIS Academy who can provide him or her additional topic information in greater depth.

Ali will be built by Value Spring Technology using the firm's enterpriseMind platform, an AI capable of deciphering and contextualizing natural human language similar to the way that the human mind works. Thus, students and teachers will be able to speak with Ali naturally. More importantly, Ali will be able to adapt to the student, learning his or her needs and modifying the teaching style as the student develops. In an upcoming article, Bill Doyle, one of the inventors of enterpriseMind, will provide greater detail about exactly how the technology works.**3D Printing a Spacecraft**

The design for the NSS Enterprise is no ordinary spacecraft. Chosen through a crowdsourcing campaign, the winning submission was from Stanley Von Medvey. The design is meant to be inspired by science fiction, and once it goes into orbit, it will be the first spacecraft with the name "Enterprise" flown in space. The spacecraft's sci-fi geometry, however, is unlike any typical satellite or shuttle, opening up new manufacturing opportunities and engineering challenges.

Made In Space, famous for now installing two 3D printers aboard the International Space Station, has been selected as the prime contractor for the construction of the NSS Enterprise. The company will leverage its expertise with additive manufacturing to 3D print the airframe of the spacecraft. To do so, Made In Space will use a modular approach, breaking the design down into individual, LEGO-like bricks before printing them and assembling them into the complete NSS Enterprise.

This method will both allow the team to print the pieces of the spacecraft on a smaller 3D printer and give the EIS team the ability to configure payloads, including perishable experiments that will needed to be loaded into the NSS Enterprise just before launch.

"Remember the game Tetris?" Zielinskiasked. "That's kind of how I envision the experiment modules inside the NSS Enterprise. They're going to be different shapes and sizes, but they're all going to fit very nicely and neatly together. Depending on the experiments that are going inside of them, the modules should be 3D printed and screwed together. The educators need to work with the engineers."

The ability to 3D print a modular, satellite-style spacecraft will also act as a demonstrator for a new technology that Made In Space is developing for NASA, a process for 3D printing and assembling large-scale structures, like satellites, from the International Space Station. If Made In Space is able to 3D print the NSS Enterprise, which is estimated to measure 8 feet long and weigh 1,000 pounds, the firm may also be able to 3D print satellites aboard the International Space Station.

Flying the Orbiter

To get the NSS Enterprise into low-Earth orbit (LEO), EIS is currently in talks with private space companies to determine if the orbiter can be carried as a secondary payload on a commercial launch vehicle. If so, the spacecraft will be deployed into LEO and coast in free drift for most of its journey, though cold gas thrusters or gyros will be used to orient the orbiter as onboard experiments dictate, say to pick up video of the Earth for a

geography class.

“One of the biggest issues, I think, is reentry,” explained Fred Becker, EIS chief engineer. Becker is a former NASA engineer who has worked on a dozen space missions, including the New Horizons Pluto mission. “A lot of that depends on the final design of the spacecraft, which is dependent on the type of launch vehicle we can get. We’re still trying to decide if the spacecraft will have more of a capsule shape or a space plane shape and whether or not it will feature a protective clamshell.”

If EIS determines that the NSS Enterprise will more closely resemble a capsule, the physics of reentry are less complex. At a certain altitude, a parachute deploys and the capsule simply falls back to Earth. A spaceplane, on the other hand, would land more like the Space Shuttle, a longer, slower reentry with the spacecraft banking left and right before a parachute deploys and the NSS Enterprise coasts to its target on land.

For reentry, the spacecraft won’t be controlled from the ground, but through onboard sensing and a predetermined programming. Of course, the EIS crew, which is still scouting their mission control outpost, will be able to take over manual control if necessary, but Becker said that he hopes to program the spacecraft to execute a reentry program after it has been in orbit after a certain amount of time, at which point a kick motor will redirect it towards Earth.

EIS is working with partner company Terminal Velocity Aerospace, a subsidiary of satellite design company SpaceWorks Enterprises, to develop the ablative coating or clamshell that will protect the spacecraft during reentry. SpaceWorks, too, is in on the project and has helped the EIS team to draw up the preliminary physics calculations for the design of the NSS Enterprise.Once EIS finds a launch provider and the $32 million necessary to begin construction on the spacecraft, SpaceWorks will finalize the designs and hand them off to Made In Space and asteroid mining company Deep Space Industries to build the orbiter.**Funding NewSpace Education**

The funding, however, is a crucial variable in the ultimate design of the spacecraft, according to Alice Hoffman, EIS program manager. Hoffman has worked as project manager on such complex projects as the $6.2 billion expansion of Chicago O’Hare airport and the Chicago Bears’ $660 million Soldier Field.

“What’s different about this is that our project schedule and our engineering are based on the ability to afford it,” Hoffman said. “Our project schedule and everything else is tied to receiving sufficient donations to go forward with certain aspects of the project. You always work backwards from the goals of the client, and our goal is to get kids interested in studying STEAM by showing them the future of what is possible in space and what sorts of jobs they might have in the NewSpace economy. That doesn’t have to be an 8-foot ship. It could be a smaller ship. The bigger ship gives us the ability to fly more serious experiments, and we want to do that, but you have to be realistic about what you can afford.”

The amount of funding the program can obtain, then, is factored into the ultimate design of the spacecraft, something that was taken into account when approaching SpaceWorks for guidance. “We had a couple of questions we wanted to ask SpaceWorks,” Hoffman explained. “If we only leave the NSS Enterpriseup for a week or two, do we need solar panels or can we just use a battery to power the spacecraft and the payloads? They concluded that we would need solar panels—that the mass ratio would be better for sustaining an average 50 watts of load for the ship and the payload if we had solar panels, even for a one- or two-week

mission.”

She continued, “The second question we asked was what would be the total mass of the NSS Enterpriseto support various payload masses. We were shooting for 300 pounds of payload, and on its preliminary estimate, SpaceWorks suggested that it would be about 1,100 pounds.”

This is where the funding comes into play: “But the answer is a curve showing mass versus payload. So, if we were to get a free launch on a vehicle that couldn’t take a spacecraft as big as the one we’re talking about or we couldn’t afford the entire project, we could scale it down and take only 200 pounds of payload, which would result in an overall smaller mass spacecraft.”

Of course, the goal is to realize the full potential of the NSS Enterprise, making it large enough to include the university-level experiments. To do so, EIS is in fundraising mode. The group is looking to obtain $20 donations from individuals, earning them virtual crew memberships on the spacecraft, as well as large donations from charitable organizations and corporations.

While $20 will get your name flown on a chip stored on the NSS Enterprise, $30 million will give you naming rights to the NSS Enterprise (Sponsored by You) and $10 million will allow you to name the artificial intelligence or choose her voice or visage. More importantly, what better way to demonstrate a commitment to education that will be a game changer than by funding the foundation of NewSpace education?