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tech spotlight:

3D Printing's Impact in the Higher Education Market

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3D Printers Support Science Research at U Houston

3D printers are overhauling teaching and research practices at the University of Houston (UH). A growing number of faculty members at the 40,000 student institution are using the devices to support their research. According to the university, scientists are using the printers to create designs in plastic, metal, ceramic and even biological tissue.

"If you can think of it, you can print it," said Tony Frankino, Assistant Professor of Biology in the College of Natural Sciences and Mathematics at the University of Houston, in a prepared statement.

Frankino used one of the lab printers to produce a set of small wind tunnels for a graduate student's research project. The Ph.D candidate used the wind tunnels to examine fruit flies and their "ability to adapt to new environments." Frankino made a smaller set of the wind tunnels for use as a visual aid at conferences and lectures.

Computer Engineering Professor Jose Luis Contreras-Vidal would like to see the printers used to help individuals suffering from movement disorders. His research aims to develop algorithms that "read electrical activity in the brain and translate it into movement." The 3D printers, he said, could be used to create custom exoskeletons with built-in motors for children with cerebral palsy. Fitted over the user's hips and legs and controlled by the brain-machine interface, the exoskeleton could be used as a therapeutic device for treating the movement disorder.

For now, though, most academics report using the printers as a way to illustrate complex concepts in the classroom. Ognjen Miljanic, Assistant Professor for the Department of Chemistry, uses the printers to produce models of crystal molecules. The molecules, too small to view with the naked eye, can be studied through the 3D models.

"I realized that models could convey some concepts much better than I could in two dimensions on the board," said Miljanic.

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Miljanic was recently named a Contrell Scholar by the Research Corporation for Science Advancement. He received the honor for his proposal about developing a database of plans for 3D models. The plan allows academics at any institution to print the models for their own use.

"The cost has dropped over the last 10 years," Miljanic noted. "The barrier now is that many people are uncomfortable trying to prepare a 3D model design."

Schools can save more than just money with 3D printers. Frankino estimated that the wind tunnel he printed out would have taken up to a year to design and $60,000 to produce. But with the 3D printer the tunnels took just two weeks to create at a cost of $2,000.

"That's pretty science fiction to me," Frankino quipped. "That's amazing."

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STEM Academy Partnership Leverages 3D Printing To Prepare Students for the Future

Lower costs and increased accessibility have helped 3D printing gain traction over the past several months, bringing a once highly specialized technology into the mainstream. Following that trend, STEM Academy, a non-profit focused on improving science, technology, engineering, and math (STEM) education for all students, has partnered with 3D printing company Stratasys to enhance STEM programming.

According to a recent announcement, integrating 3D printers into STEM education gives students an opportunity to prototype three-dimensional objects and designs in the classroom setting, adding to the overall learning experience. The new partnership will also give participants a chance to build a portfolio that translates into the current marketplace, enhancing 21st century skills and better preparing them for internships and other career opportunities after graduation.

"The manifestation of true STEM education is students solving open-ended problems," said Russell Mickelson, CEO of The STEM Academy, in a prepared statement. "It is this critical thinking capability which elevates testing results. When true STEM education practice incorporates 21st century real-world application, students are prepared to compete in the global economy. Partnering with the global leader in Stratasys will allow the schools we serve the opportunity to provide students with unique, real-world 21st century experiences in the classroom."

The partnership with Stratasys is the latest in a string of STEM Academy collaborations intended to promote and enhance STEM education across the country.

New Stratasys 3D Printer Incorporates Multiple Colors and Materials

Stratasys has introduced the Objet500 Connex3 Color Multi-Material 3D Printer, able to print in multiple colors and materials in a single run. The printer's triple-jetting technology combines droplets of three base materials to produce parts with multiple combinations of rigid, flexible and transparent color materials as well as color digital materials. That means a user can achieve the characteristics of an assembled part without assembly or painting.

Three color materials — VeroCyan, VeroMagenta and VeroYellow — are used to produce the printer's color palette. A range of PolyJet photopolymer materials are available, including digital materials; rigid; rubber-like; transparent; and high-temperature materials to simulate standard and high-temperature engineering plastics. The Objet500 Connex3 also allows overmolding using Digital ABS materials and introduces new Shore A values for Digital ABS, ranging from A27 to A95. Six palettes for new rubber-like Tango colors range from opaque to transparent colors in various shore values.

The Objet500 Connex3 boasts a large build envelope, suitable for high-capacity production. Print jobs can run with about 30kg of resin per cycle, and with a resolution as fine as 16 micron layers.

For more information and specs, go to the Stratasys site.

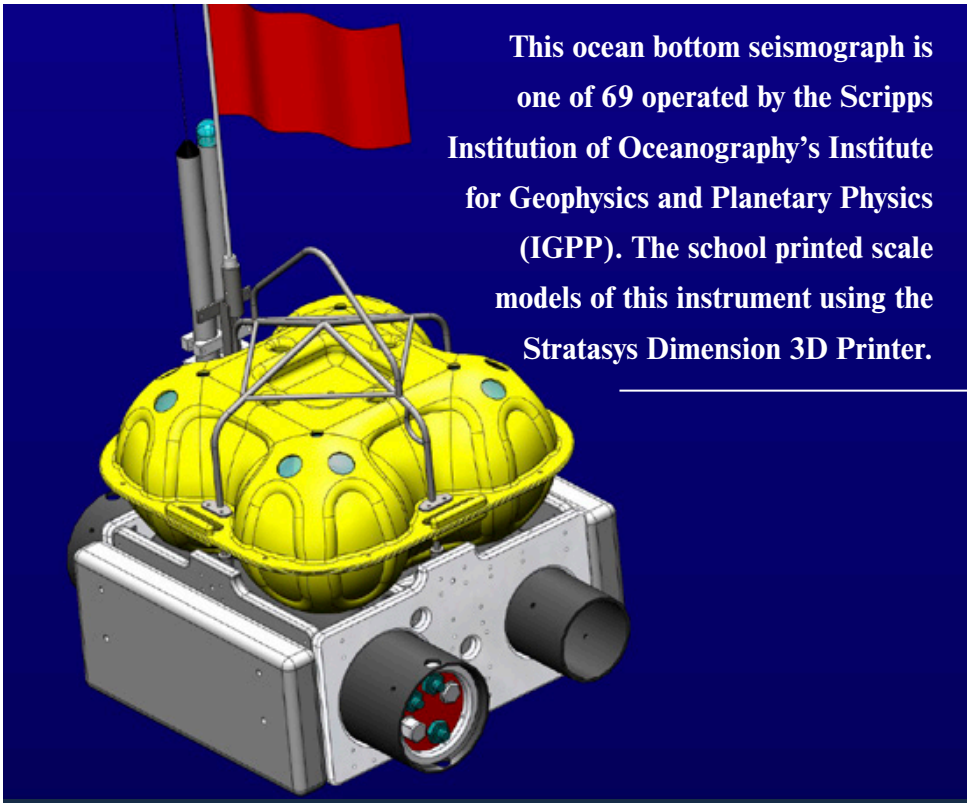
Scripps Institution Goes Deep

Researchers Rely on Rapid Prototyping to Build Replacement Parts for Deep-Sea Research Vehicles

Martin Rapa, developmental engineer for the Scripps Institution of Oceanography's Institute for Geophysics and Planetary Physics (IGPP), is responsible for designing and implementing deep-sea seismic research equipment. With help from a handful of students in the engineering department participating in a paid internship program, Rapa produces every component for the Institute's ocean bottom seismology instruments.

"Our equipment packages are installed in half-ton, free-fall vehicles, deployed on ships all over the world," Rapa said. "When it gets to the bottom, the vehicle records earthquakes and collects seismic data, giving scientists a better understanding of deep earth processes."

Rapa's students are well versed in using 3D computer-aided design (CAD) software to create prototypes and parts for deep-sea instruments, but waiting for functional machine-made prototypes became costly and inefficient, often delaying deployment for weeks or months at a time while waiting for the next research vessel to depart. Over several years, IGPP spent thousands of dollars developing full-scale prototypes and either machining them by hand on-site or sending the designs to a third party for fabrication.



This ocean bottom seismograph is one of 69 operated by the Scripps Institution of Oceanography's Institute for Geophysics and Planetary Physics (IGPP). The school printed scale models of this instrument using the Stratasys Dimension 3D Printer.

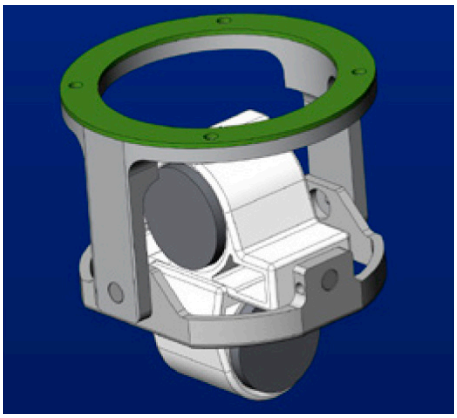
"We were looking for a way to streamline the production of functional parts and prototypes, including instrument molds and scale models, in order to allow more rapid development and deployment of new ideas," said Rapa. "We also wanted to give students a break from hands-on machining in the shop, which is not very cost-effective or appropriate for their skills training."

> "Any university that wants to keep up with the latest manufacturing technology should consider a Dimension 3D Printer."
>
> — Martin Rapa, Scripps Institution of Oceanography

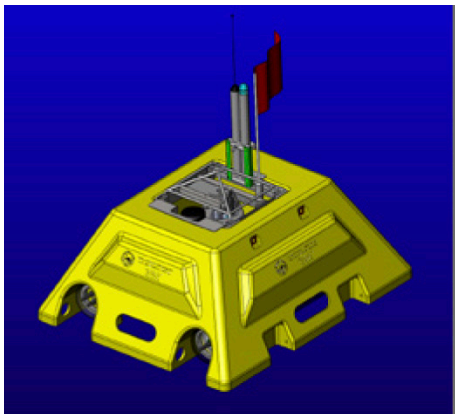
Since purchasing the Stratasys Dimension 3D Printer, the IGPP has seen a 50 percent reduction in time and expense incurred for parts manufacturing, allowing the Institute to deploy new instrument packages faster and more cost-effectively than ever before.

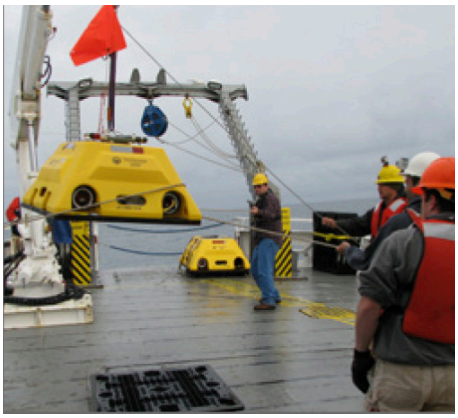
IGPP Deep-Sixes Costly Overtime, Production Costs

Manufacturing new instruments and functional prototypes is now easier and more efficient, with the IGPP team better able to respond to immediate, mission-critical needs. During a recent deployment, a polyethylene beacon bracket on one of the instruments broke during routine service. With a ship ready to



Martin Rapa and his team designed this new, trawl-resistant seismometer platform using the Dimension 3D Printer. The Scripps Institution uses the models for underwater stability testing.





The above images are an actual Scripps Institution seismometer being deployed off the coast of Oregon. The Stratasys Dimension 3D Printer plays a critical role in designing and building functional parts for these instruments.

depart the next day, there was no time to get a replacement part fabricated without paying exorbitant overtime charges.

"Since ABS is relatively porous compared to polyethylene, we weren't sure how the part would perform at 1,000-meter depths," Rapa said. "But the part was already designed, so rather than paying overtime and overnight delivery charges, we went ahead and fabricated it using the Dimension 3D Printer. We saved thousands of dollars and the part performed flawlessly."

IGPP also has the ability to construct several full-scale prototypes for each instrument it designs. Prior to getting the Dimension 3D Printer, the Institute didn't have the luxury of modifying designs or constructing several iterations of the same prototype. At a cost of $30,000 each for full-scale prototypes using previous methods, the Dimension 3D Printer saved IGPP significant time and money, and allowed the Institute to have more precise control over instrument design.

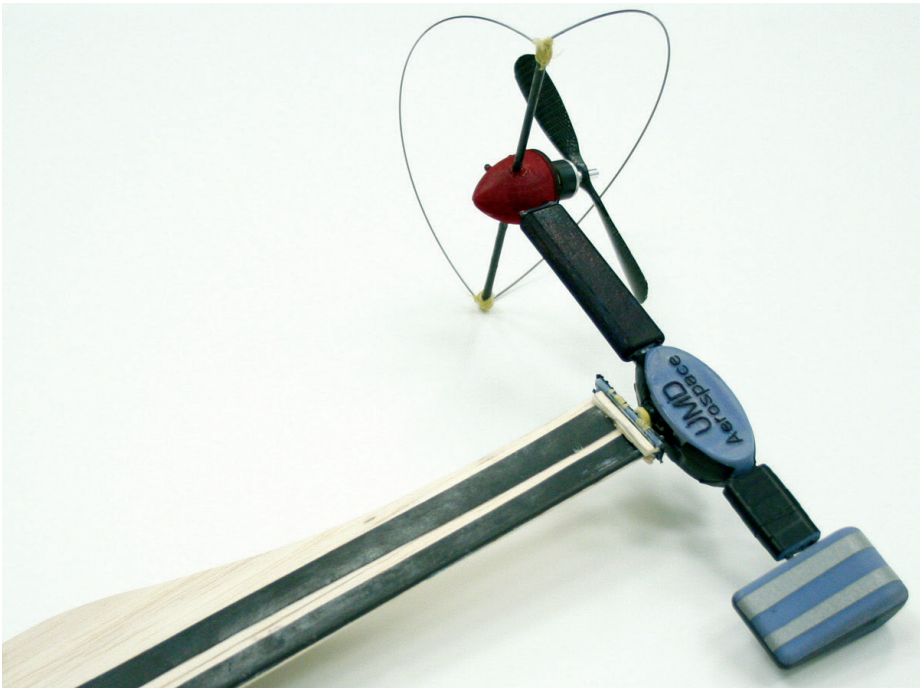
Rapa can easily amortize the cost savings realized with his 3D printer, and anticipates recouping the full cost of the unit within four to five years. To help further defray the cost of the unit, Rapa also makes the 3D printer available to other groups for a nominal charge, running parts for other design and engineering groups at the Institute when his team isn't using it.

"There's a more than fifty-fold difference between creating functional parts in the shop versus fabricating them with the Dimension 3D Printer," Rapa said.

Research Instruments Bring Deeper Understanding of Ocean Floor

IGPP's deep-ocean instruments provide significant research advantages to scientists studying the earth's crust and geological processes associated with underwater volcanoes and earthquakes. Focusing on ocean-floor regions at high risk for seismic activity, researchers use IGPP's instruments to identify high stress points. Seismologists can then get high-resolution pictures of ocean-floor tectonics, or deeper broadband measurements of deep-earth processes, to improve earthquake and tsunami preparedness.

"One of our current projects is a new instrument for the (U.S.) Pacific Northwest, a region many scientists feel is under-prepared for seismic activity," said Rapa. "Having the Dimension 3D Printer means we can design, troubleshoot and perfect this equipment more efficiently, and provide even more value to the scientists who process the data."



Top Flight

University of Maryland Enhances Research Validity with Objet 3D Printer

The University of Maryland has improved aerospace research by using 3D printing to compress the prototype development cycle.

For over 50 years, the Department of Aerospace Engineering at the University of Maryland A. James Clark School of Engineering has achieved breakthroughs in understanding flight, exploring space and designing aerospace components, vehicles and systems. The school's research laboratories focus on areas such as advanced propulsion, composites and hypersonics. Among its distinguished alumni are aviation pioneer Glenn L. Martin and former U.S. National Aeronautics and Space Administration (NASA) head Michael D. Griffin.

The department has received funding from the U.S. Army for a wide range of projects including the analysis of alternate modes of flight for potential military applications. As part of their research in this area, faculty and Ph.D students frequently subject numerous identical prototypes to the same experiment over and over to ensure testing validity. This requires engineers to create multiple, often tiny, test objects with 100 percent identical characteristics.

Stratasys Objet Eden350V selected as the best solution due to high resolution,accuracy and durability of models

For years the department sought a better way to produce large volumes of highly accurate prototypes. Recently, under the direction of Professor Darryll Pines, former department chair and now dean of the Clark School, several 3D printing technologies were explored to improve the testing process. "Objet was selected based on its exceptional resolution, accuracy, printing detail and durability," said Pines, who oversaw the department's acquisition of the Objet Eden350V™ 3D Printer.

The Objet Eden 3D Printer had an immediate impact on productivity. "Our 3D printer reduces the prototype development cycle by a full year and yields a cost savings of approximately $80,000 per year," said Evan R. Ulrich, graduate research assistant candidate in the department. "It eliminates the need to pay for prototype material such as aluminum and plastics that outside vendors marked up by nearly 1000%. Most importantly, our Objet 3D Printer enhances the validity of our research

At a Glance

Challenges

- University of Maryland researchers sought to reduce errors, increase productivity and improve the validity of research findings

Solution

- Stratasys Objet Eden350V 3D Printer

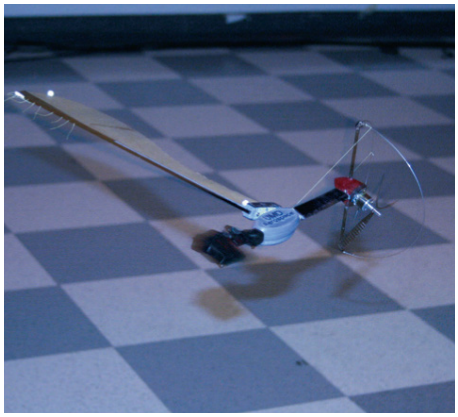
Results

- Significantly reduced errors and costs
- Increased validity of results
- Sped up the testing process by one year

"Objet 3D printing technology has substantially improved our research and testing capabilities, enabling us to achieve new discoveries and recruit the best and brightest emerging engineers."

— Prof. Darryll Pines, University of Maryland

Department of Aerospace Engineering requires large numbers of prototypes.



The Stratasys Objet Eden350V was selected based on its exceptional resolution and accuracy.

The 3D printer reduced the prototype development cycle by a year.

findings by ensuring that test objects are always 100% identical."

According to Ulrich, all aspects of the testing apparatus are now constructed with the Objet 3D Printer. "There's no waiting on other people, as we can produce our models inhouse much faster than before," he said. "This machine has fundamentally improved our overall process, revolutionizing our research capabilities."

Pioneering the next generation of aerospace breakthroughs

One application was in the study of how insects avoid obstacles during flight. The department employed the Stratasys 3D printer in the design and manufacture of a structure used on board small helicopters to test for close obstacle avoidance. "The Objet Eden system reduced by months the time required to complete this research," Ulrich said.

Ulrich uses the Objet 3D Printer to study flight patterns of winged plant seeds falling from trees for potential applications in unmanned aerial vehicles (UAVs). "UAVs are often limited by the power required to simultaneously maintain flight and operate onboard electronics," Ulrich said. The flight mode exhibited by winged seeds requires little to no power. Using the Objet Eden 3D Printer he was able to cost effectively test numerous design iterations leading to the invention of the smallest controllable robotic samara to date. A samara is a controllable monocopter that can autorotate like a maple seed and fly like a helicopter.

In addition, Ulrich and fellow students used the Objet Eden 3D Printer to create a model for the annual Cessna/Raytheon Missile Systems Student Design/Build/Fly competition. Run by the American Institute for Aeronautics and Astronautics, the contest challenges students to design, fabricate and fly an unmanned, electric-powered, radio-controlled aircraft. The students' model had a four-foot wingspan and was built to close tolerances for accurate wind tunnel testing. The Maryland team finished very high in the competition and the companies that supplied the wind tunnels were so impressed that they researched the potential of Objet 3D Printers for their own testing processes, according to Ulrich.

"Objet 3D Printers can help engineers and those who train them to better execute technical research studies," said Pines. "It represents the future of aerospace studies and will surely help our best minds achieve the next generation of scientific breakthroughs."

Completed fencing swords and prototype hilts

Olympic Precision

Iterative design contributes to success at the London games

One of Japan's top schools, the University of Tsukuba is renowned for its work in sports science and Olympic education, and for developing several of the country's best athletes. In 2011, the university began research and development projects as part of the Team Nippon Multi-Support Project, a program initiated by the Ministry of Education, Culture, Sports, Science and Technology to provide advanced support to Japanese Olympic athletes and teams.

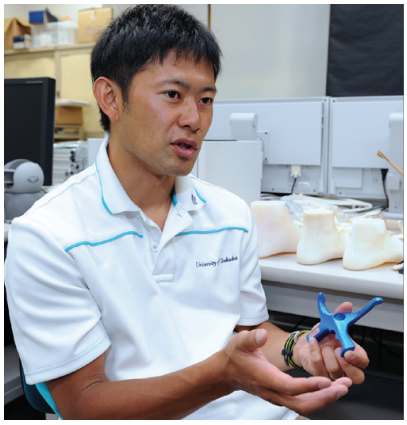
The projects focus on developing sports equipment as well as training and conditioning methods. Already, results include gymnastic protective gear, shoes for javelin throwers, clothing for triathletes, masts for Olympic sailing yachts and a system to analyze badminton footwork. Most notably, the program developed the hilt, or handle, of the fencing foil for Japan's 2012 London Olympics team.

Refining the Athlete's Foil

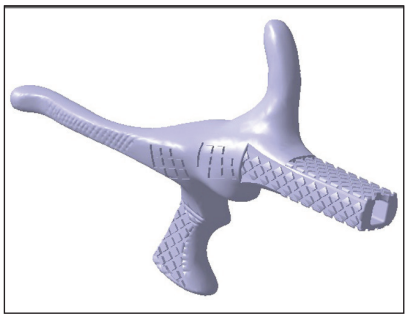
Every fencing foil is different, tailor-made to the athlete. Fencers traditionally hand-sand their hilts to adjust the fit and feel for optimal control. If a hilt breaks, it is irreplaceable.

When he was assigned to create new hilts for the Olympic team, Osamu Takeda, a researcher in sports biomechanics at the University of Tsukuba, was reluctant. He knew little about fencing and its rules, let alone the intricacies of how to grip the foil. With just months to complete production and deliver the final products in time for the London Olympics, time-intensive molded or machined prototypes were out of the question, says Takeda.

Thankfully, the university's Sport Performance and Clinic Laboratory had installed an Stratasys Objet350 Connex™ 3D Printer for the multi-support project. Over six months, Takeda made nearly 70 prototypes. "It was only possible with this 3D printer," he says. Some prototypes were built in just hours, and the PolyJet™ technology-based system provided the impressively fine resolution needed for Olympic-quality product development. The 3D printer produces smooth prototypes with layers just 16 microns thick.



Osamu Takeda worked directly with Olympic fencers to develop customized hilts for each athlete.



Athletes gave feedback on many iterations, resulting in optimal control.

"Athletes are not engineers. So I needed to translate their words into several prototypes as quickly as I could. Without 3D printing, it would not have been possible."

— Osamu Takeda, University of Tsukuba

Skepticism Turns to Trust

Takeda's strategy was to use the team's existing hilts for the development base. He scanned the hilts, input the 3D polygon data into his 3D CAD system and fed the new data in STL format into the 3D printer's software to generate the first prototypes.

Team members were skeptical of someone unfamiliar with their sport developing new hilts, but their doubts were skewered when they saw Takeda's first prototypes. "They were surprised by the prototypes' quality and started making customization requests," he says.

Having gained the team's trust, Takeda moved diligently forward on his mission, several iterations at a time. He often appeared with five to seven new prototypes within a day of fencers' requests. "Athletes are not engineers. So, I needed to translate their words into several prototypes as quickly as I could. Without 3D printing, it would not have been possible."

Peace of Mind

In April 2012, a few months before the London Olympics, final production was complete. Even the original hand-finished, non-slip pattern on the surface of each hilt was reproduced exactly. Takeda provided the team with a set of five new hilts for each member. "Now they have replacements, even if a hilt is broken. Probably, that is the biggest result of the project. Those replacements gave the athletes peace of mind during the competition." The team's silver medals are Takeda's proof. And Takeda predicts wider benefits: "No one can say that our efforts for top athletes won't result in better sports gear for the general public someday."

Stratasys Objet350 Connex at the Sport Performance and Clinic Laboratory

To learn how more educators are using 3D printing or to find a reseller, please visit us at **www.stratasys.com/industries/education**