Harnessing the Power of Additive Manufacturing for Transformative Academic Research

Solution Guide

stratasys

Harnessing the Power of Additive Manufacturing for Transformative Academic Research

The use of 3D printing for higher education research has been on the rise in research centers and universities across the world. Educational institutions are leading innovation and research through their use of additive manufacturing technologies such as Fused Deposition Modeling, Material Jetting, Stereolithography, Powder Bed Fusion and more for advanced research. With this guide as a resource, readers will gain a better insight into the incredible potential that 3D printing provides for educational research initiatives across the globe. From custom medical devices to advances in prosthetic engineering, 3D printing creates a world of opportunity for research centers and universities looking to bring cutting-edge solutions to life.

What is the connection between 3D printing and Educational Research?

3D printing is an exciting technology with vast potential implications for the future of research in higher education. 3D printing at its core is the process of creating objects by building them layer-by-layer using inputs from digital technology as opposed to traditional model making. 3D printing allows researchers to create components or tools on demand and on campus without limitations. Moreover, this technology has enabled new methods of teaching both at universities and research centers where students are exposed to the entire design process, giving them greater hands on learning experience. As the potentials of such technology become more apparent in the years ahead, it's clear that 3D printing will have increasingly important roles for research within higher education institutions through simulation-based studies and digital fabrication processes of physical laboratory instruments.

"Voxel-controlled 3D printing allows us to create microstructure and macroscopic products at a scale and resolution that's unprecedented."

Martin Dunn, Associate Provost for Research
Singapore University of Technology and Design, Digital Manufacturing and Design Center

Unlocking New Levels of Design

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How can researchers use 3D printing technologies for their projects?

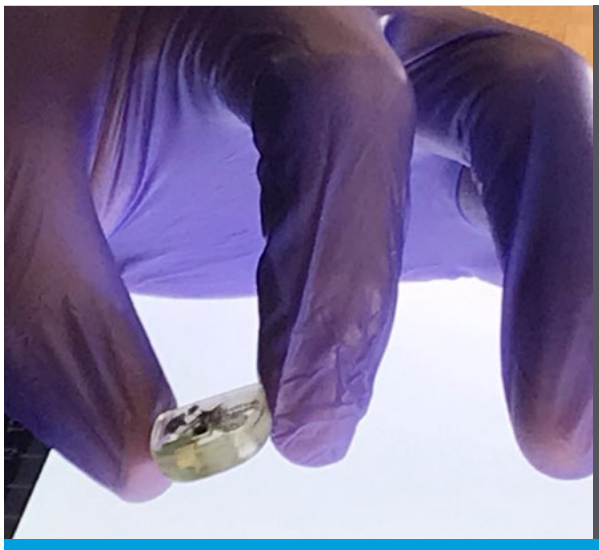
Researchers at universities have more opportunities than ever for creative solutions for their studies and projects thanks to 3D printing technologies. From medical research to computer science explorations, these powerful printers can build 3D models of complex objects with incredible precision, greatly increasing the potential applications of a researcher's ideas. Even intricate components that may have been difficult or expensive to produce can be recreated in just a few hours. This technology allows researchers to create physical copies of something they designed digitally on screen, giving them the chance to experiment with different designs and perfect their work. Whether used to test out new materials or simulate phenomena such as the forces between objects, 3D printing is becoming an increasingly popular tool for cutting-edge educational research.

What benefits does additive manufacturing offer educational research initiatives?

The increased use of 3D printing in educational research initiatives offers many advantages and opportunities to today's students and researchers. For example, 3D printing makes it easier for instructors to demonstrate complex concepts and scientific contributions with tangible objects, which helps bring theories and research to life for their students. It also reduces the amount of money spent on physical models by institutions as well as enabling a more tailorable learning experience for each student based on their individual needs and interests. Furthermore, 3D printing in educational settings offers an enticing platform for sparking creativity and inspiring innovation among youthful minds from all types of backgrounds. By providing instructors with the resources, they can give students the benefit of hands-on training, an imaginative approach to problem solving is enabled that can help foster brighter futures and better researchers overall.

How can educators make the most of 3D printing technologies?

With the recent surge of 3D printing technologies, researchers at universities and research centers are in a unique position to take advantage of its innovative capabilities. 3D printing technology offers unprecedented opportunities to rapidly explore ideas—allowing researchers to create tangible models within a fraction of the time that was previously possible. By utilizing these powerful advances in technology, researchers can be better equipped in driving forward advancements and innovations for many years to come. With such powerful tools available, researchers will be able to explore new areas of inquiry and develop groundbreaking solutions quickly and with greater accuracy than before.



We are building design tools that help us to address the billions of voxels that are available in this multi-material design space. So, we're trying to make it easier for people to describe 3D models in that space. We're also creating tools that allow users to verify that a print will be printable with their original intent."

Rob MacCurdy Professor,
University of Colorado Boulder

Bringing Innovation to 3D Printing

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What the researchers are saying.

The Victoria University of Wellington in New Zealand designed 3D printed models with intricate, internal channels that perform just like the vascular systems in plants, evoking the beauty of natural pollination. According to Nicole Hone, Industrial Designer and Alumni of MADE (Multi-property Additive-manufacturing Design Experiments) at the Victoria University of Wellington, “This research project demonstrates the dynamic qualities of 4D printing by creating 3D prints that can function and change their aesthetic as various mediums flow through their internal channels; water, air, smoke, icing sugar, bubble mixture and soap.” **Read more**

INFN (Istituto Nazionale di Fisica Nucleare) Frascati branch is INFN’s largest lab, housing a Design and Mechanical Engineering department with a strong reputation for deploying disruptive technologies to conduct its experiments. See how they overcame research production challenges using additive manufacturing with help from Stratasys FDM technology. **Read more**

3D Printing provides a wealth of opportunities to the higher educational sector, and can help unlock amazing possibilities that lead to growth in innovation. Reach out to us today to discover a whole world of potential advancements.

The Otis College Art & Design Fashion Show represents the fashion industry’s future and the potential 3DFashion technology brings to the fashion world - allowing full-color, clear, multi-material printing directly onto fabric, delivering fantastic optical illusionary effects and spectacular designs that simply cannot be achieved any other way.

Chair of the Otis Fashion Department, Jill Higashi Zeleznik, says, “Stratasys 3DFashion Technology unlocks an extraordinary realm of limitless creativity, offering an awe-inspiring opportunity for all who yearn to push the boundaries of imagination.”**Read more**

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Stratasys 3D Printing Technologies for Research

Stratasys offers different polymer-based 3D printing technologies that cover a large spectrum of research needs.

FDM®
Fused Deposition Modeling

FDM systems are the most widely used form of 3D printing. FDM 3D printing is a cost-effective, versatile, and easy-to-use technology that is well-suited for research applications enabling researchers to quickly prototype and fabricate custom parts and components. FDM 3D printers build parts layer by layer from the bottom up by heating and extruding thermoplastic filament. FDM technology is a popular technology for research due to several reasons:

- **Affordability:** FDM 3D printers are relatively inexpensive compared to other types of 3D printers, making them more accessible for researchers with limited budgets.
- **Ease to use:** FDM 3D printers are easy to set up and operate and require minimal technical expertise. This makes them a good option for researchers who are new to 3D printing.
- **Versatility:** FDM 3D printers can use a wide range of materials, including thermoplastics, composites, and even some metals. This makes them versatile for different research applications and projects.
- **Materials choice:** Best-in-class material portfolio, from basic ABS to engineer-grade thermoplastics.

P3™ Programmable PhotoPolymerization

Stratasys Programmable Photopolymerization P3™ technology is the next level of DLP, a fast, versatile, and highly precise 3D printing technology. DLP 3D printing is faster than other type of 3D printing as it can cure entire layers of resin at once using a light source. This allows for quicker fabrication of parts and components.

P3 is an advanced technology for research for several reasons:

- **Part accuracy and detail:** P3 prints parts and components with exceptional part quality and detail, repeatedly.
- **Materials versatility:** P3 is an open system that can run a variety of high performance and production-grade materials, including resins that can be specifically tailored for different research applications. This versatility allows researchers to choose the most appropriate material for their specific research needs or to develop and validate new materials all together.

PolyJet™
Photopolymer Jetting

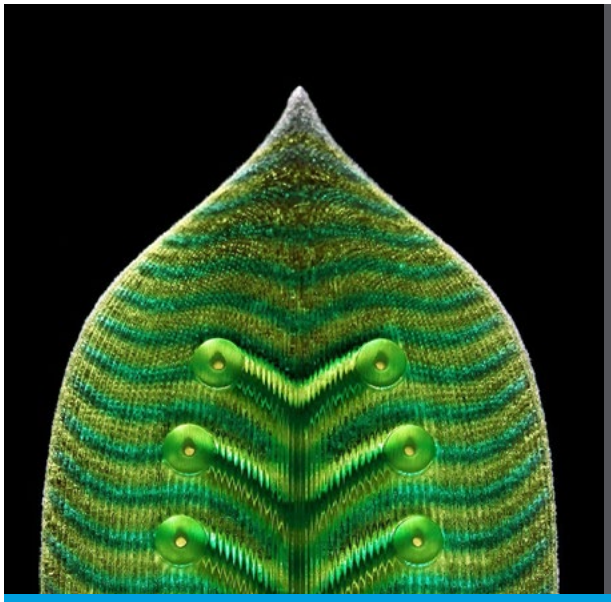
PolyJet 3D Printing is an advanced photopolymer technology where droplets of material are deposited in successive layers and exposed to UV light to build a part. It has the ability to mimic virtually any other material, resulting in parts that boast unparalleled realism.

PolyJet offers a wide range of capabilities, including the creation of complex geometries, intricate details, full-color combinations, transparencies, and flexible parts - all in a single model - bringing your ideas to life with exceptional precision and versatility.

Researchers using PolyJet technology can appreciate:

- The realistic, detailed models with a smooth surface finish and complex textures
- Having options for rigid to rubber-like, and opaque to transparent in a single print job
- Gel-like support materials for easy removal by hand or with regular tap water

Additional Research Package software unlocks some of the most advanced applications for research (see appendix).



Expanding 3D printing technology to create 4D liquid printed structures that imitate living organisms.

"PolyJet basically extracts every minute detail from the computer and the PolyJet Research Package added the additional capabilities needed to literally take us to a fourth dimension."

Ross Stevens
Senior Lecturer for Industrial Design and Founder of MADE
Victoria University of Wellington

FIND OUT MORE

3DFashion™
Direct-to-textile 3D printing

Powered by PolyJet technology, 3DFashion is making waves among the fashion world with its revolutionary 3D printing technology. For the first time, 3D algorithms can be used on fabric to create fascinating illusions with color and light that are luminous to behold and magic to the eye.

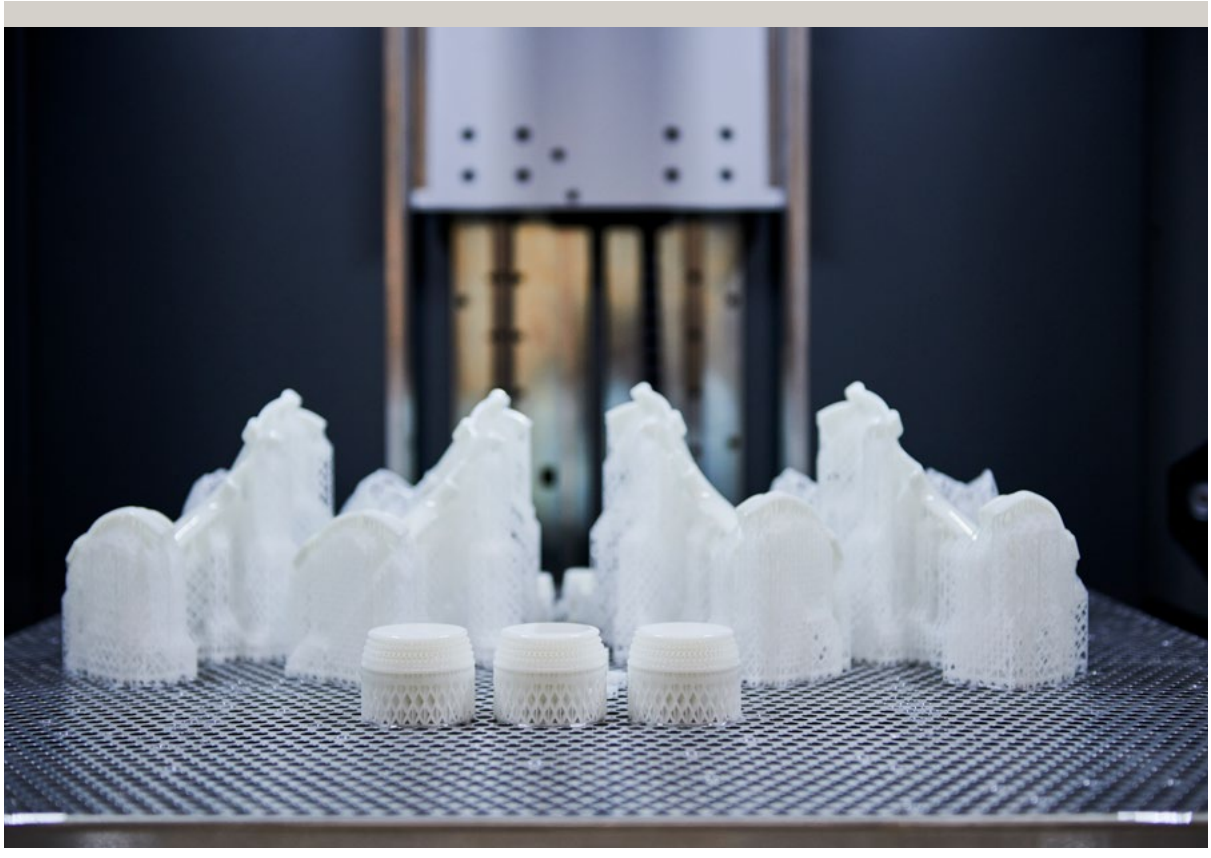
3DFashion enables students to truly unleash their imagination with limitless creations and unparalleled flexibility.

SAF™
Selective Absorption Fusion™

SAF is a powder bed fusion technology developed by Stratasys specifically for higher-volume production. It is a versatile and highly precise technology that is well-suited for advanced manufacturing research applications. It enables researchers to quickly prototype and fabricate highly customized parts and components with a high level of precision and accuracy.

Neo®
Stereolithography

Stereolithography (SLA) is an additive manufacturing process that uses a vat of liquid UV-curable photopolymer resin and a UV laser to build parts one layer at a time creating parts with excellent detail and exceptional surface finish. This makes it another optimal technology for high-fidelity prototypes and concept models, including clear parts for applications requiring testing such as fluid flow analysis.



3D Printing
Materials and Research

3D printing technology has come a long way and with the expansion of material choices comes greater possibilities. Researchers can select from a wide range of thermoplastic polymers, photopolymers, and composites depending on their desired application. Stratasys has validated their materials, whether developed in house or from their materials partners, to work seamlessly with their printer technology. With all this versatility at hand, 3D printing is an invaluable asset for a variety of research applications. Read more.

Technology Highlights	
FDM	• Wide range of available thermoplastics – engineering grade to high-performance • Includes carbon and glass-filled materials for high-strength applications
PolyJet	• Thermoset resins with many color options and combinations • Capable of many characteristics – transparent, opaque, rigid, pliable
P3	• A portfolio of production-grade materials developed by industry leaders in polymer technology. • Includes materials suitable for demanding manufacturing applications – including flexible materials and FST-rated materials
SAF	• PA11 and PA12 nylon powders suitable for a wide range of applications
Stereolithography	• Assorted range of resins offering suitability for diverse set of applications • Resins with superior clarity, structural integrity, and thermal resistance

APPENDIX 1
Research 3D Printing Use Cases

3D printing has become a valuable tool for research in higher education, providing a way for researchers to produce physical models and prototypes quickly and easily for a wide range of applications. Here are some ways 3D printing is used for research in higher education:

- **Rapid Prototyping:** Researchers in higher education use 3D printing to rapidly create prototypes of their designs. This allows them to quickly iterate on their designs and test their ideas without the need for expensive tooling or lengthy lead times.
- **Biomedical Research:** 3D printing has been used in biomedical research to create anatomical models of organs, tissues, and bones for surgical planning and simulation. It has also been used to create custom implants and prosthetics that are tailored to individual patients.
- **Materials Science Research:** 3D printing has been used in materials science research to create complex structures and composites that would be difficult or impossible to produce using traditional manufacturing methods. Researchers can use 3D printing to create unique material compositions with specific properties and test their performance under different conditions.
- **Microfluidics:** 3D printing is used to produce microfluidic devices with complex geometries that are difficult to manufacture using traditional methods. They are essential tools for studying the behavior of cells, fluids, and biochemical reactions on a small scale, they mimic physiological conditions, enabling the study of cell behavior, drug screening, and disease modeling with greater accuracy and control. Microfluidic devices often require the integration of multiple components, such as pumps, sensors, and electrodes: 3D printing enables the integration of these components into a single device, simplifying the fabrication process.
- **Architecture and Design:** 3D printing has been used in architecture and design research to create models of buildings and urban environments, allowing researchers to visualize and test their designs before construction. It allows researchers to explore new design concepts, construction techniques, and building systems in a tangible and practical way. It also enables the testing and validation of theoretical models, structural performance, and functional aspects of architectural designs.
- **Education and Outreach:** 3D printing has also been used in higher education to teach students about design and manufacturing processes. It provides a way for students to gain hands-on experience with the technology and learn about the different applications of 3D printing in research and industry.

The following table provides examples of different case studies and use cases powered by Stratasys 3D Printing technologies in different research areas.

DEPARTMENT / RESEARCH AREA	APPLICATION / USE CASES	CASE STUDIES / USE CASES	
Hydraulics and fluidic models	Victoria University of Wellington	Expanding 3D printing technology to create 4D liquid printed structures that imitate living organisms.	LINK
Mechanical Engineering	University of Colorado Boulder	Liquid–solid co-printing of multi-material 3D fluidic devices via material jetting	LINK
Materials Engineering	University of Washington	Researchers created a new grip to reduce the sander vibration with Boeing - from the development of an exclusive digital material to how students worked with 3D printing to get to the final design	LINK1
Engineering Electronics	OTH Regensburg	OTH is home to the Sensorik-Applikationszentrum (SappZ), a center where students use applied research and engineering together with 3D printing to develop sensor applications for the automotive, medical, industrial, electronic and mechanical industries	LINK
Computational Design / Microstructures	Technion – Israel Institute of Technology	Technion explores applications of 3D printed heterogeneous microstructures.	LINK
Computational Design	MIT Media Lab	Take advantage of the multi-material capabilities of PolyJet Technology and GrabCad Voxel Print to create illusory materials, something that wasn't possible with traditional material design.	LINK1 LINK2 LINK3
Computational Design	Singapore University of Technology and Design (SUTD)	Learn how researchers explore groundbreaking design at a microscopic scale with GrabCAD Voxel Print.	LINK
Computational Design	Lancaster University	Lancaster University pushes design limits with GrabCad Voxel Print technology.	LINK
Chemistry	Saint Louis University	3D Printing Microfluidics with PolyJet Technology	LINK
Chemistry	Saint Louis University	PolyJet-Based 3D Printing against Micro molds to Produce Channel Structures for Microchip Electrophoresis	LINK
Soft Robotics	Various Universities	Fully 3D-printed soft robots with integrated fluidic circuitry	LINK
Robotics	University of Colorado – Boulder	Use advanced tools and software to implement multi-material printing to enhance the structure and functionality of his 3D printed robots.	LINK1 LINK2
Biomedical	University of Colorado	Defining Soft Tissue: Bitmap Printing of Soft Tissue for Surgical Planning	LINK
Biomedical	University of Colorado	Voxel Printing Anatomy: Design and Fabrication of Realistic, Presurgical Planning Models through Bitmap Printing	LINK
Medical Research	Jacob Institute	Jacobs Institute shapes the future of vascular health with the help of Stratasys medical modeling	LINK
Medical Research	University of Minnesota	UMN Visible Heart Laboratory leverages Digital Anatomy 3D printing	LINK
Medical Research	Clackson College	Unique 3D Printing Education Program Powered by Stratasys Digital Anatomy Technology	LINK
Fashion Design	Otis College of Art & Design	A Call of Duty-inspired fashion show pushes creativity with 3DFashion	LINK
Fashion Design	Fashion Institute of Technology (FIT)	An award-winning garment with 3D sections printed on Stratasys J850 TechStyle	LINK
Fashion Design	The Hong Kong Polytechnic University	Solving poor surface adhesion on personalised garments with Stratasys J850 TechStyle	LINK

APPENDIX 2

Advanced 3D Printing Tools for Research

PolyJet™ Research Package

The Stratasys PolyJet™ Research Package represents a highly sophisticated software tool designed to offer unparalleled versatility in the realm of prototype printing. It serves as an invaluable resource for researchers and developers worldwide, providing them with an advanced array of tools that extend the capabilities of Stratasys J8™ and J7™ series 3D printers. By harnessing the power of multi-material 3D printing, this package empowers researchers to achieve extraordinary results while saving significant time and generating groundbreaking prototypes.

The PolyJet™ Research Package offers a multitude of benefits to researchers seeking to present their findings through vivid 3D printed models. It serves as a catalyst for accelerating design iterations, allowing for swift exploration and refinement of concepts.

Unique features enabled by PolyJet™ Research Package:

- **Pause print** - Pause and resume printing at a specific slice or height to insert electronics or mechanical parts in the model.
- **Air print** - Use air as a print material to create voids in which electronics or smart devices can be inserted, manage textures, or model weight and create finished surfaces.
- **Liquid print** - Print liquid materials for soft parts, hydraulics, or fluidic models in exquisite detail.
- **Visualization Support** - Increase your ability to design and produce with the option to visualize your work at every stage of the process.
- **Advanced Voxel Printing** - Define data volumetrically for each 3D voxel throughout the entire model allowing for an advanced level of control at a microscopic scale, enabling higher resolutions, fine-tuned color placement, and Shore value transitions within one part.
- **Parameters editor** - Control print parameters such as scale, offset carpet height and pedestal height with GrabCAD™ Print software

Voxel Printing

Voxel printing is a type of 3D printing that uses voxels, which are three-dimensional pixels, as the building blocks for creating 3D objects. Unlike traditional 3D printing, which uses layers to build up a 3D object, voxel printing uses a volumetric approach, where voxels are used to build up the object in a continuous fashion. In voxel printing, a digital model of the object is converted into a voxel representation, where each voxel represents a small volume of space in the final object. The printer then uses this voxel representation to create the object by selectively depositing or solidifying material in each voxel.

Voxel printing allows for greater control over the internal structure of the object, as each voxel can be individually controlled and manipulated. This can be useful in creating objects with complex internal geometries or in designing objects with specific material properties, such as high strength or flexibility.

Stratasys GrabCAD software lets you exercise control of your design at the voxel level outside of CAD software packages. With GrabCAD, your system becomes far more than a high-end 3D printer, it's a powerful platform for advanced research and development.

USA - Headquarters
7665 Commerce Way
Eden Prairie, MN 55344, USA
+1 952 937 3000

ISRAEL - Headquarters
1 Holtzman St., Science Park
PO Box 2496
Rehovot 76124, Israel
+972 74 745 4000

stratasys.com
ISO 9001:2015 Certified

EMEA
Airport Boulevard B 120
77836 Rheinmünster, Germany
+49 7229 7772 0

South Asia
1F A3, Ninghui Plaza
No.718 Lingshi Road
Shanghai, China
Tel: +86 21 3319 6000

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