PURDUE UNIVERSITY | Bechtel Innovation Design Center

BECHTEL INNOVATION DESIGN CENTER 2020 ANNUAL REPORT

FROM THE DIRECTOR

Greetings from the Bechtel Innovation Design Center. I would like to start by thanking our student employees; during any normal year, the Center would struggle without their commitment and aptitude. However, in these challenging times I cannot conceive of how the Center could have met Purdue students' needs without the commitment of our student employees. In addition, the continued strong backing of our corporate sponsors has been critical in the introduction of new technologies and the expansion of our education. Kennametal continues to provide its world-leading tooling and technical support. Our relationship with Autodesk has deepened with an NDA in place for our detailed partnership covering advanced CAD/CAM. Haas provides support for students and our CNCs. Raptor TE-CO has partnered with us on acquiring/deploying its quick-change work holding and Master Fluid Solutions for critical engineering supplies, lab testing and know-how.

The mission of the Bechtel Innovation Design Center is to be a responsive, student-focused and student-led educational community providing training, support and access to Purdue students to make their projects. On that basis, 2020 has been a smashing success. The next generation of student engineering leadership, mentored and grown at the Center, is evident in these novel processes and achievements:

1. Ground-up redesign and deployment of volunteering program for prospective student employees
2. Accessible 3D metal printing in the Prototyping lab
3. 3D metal laser cutting both sheet and tube coping
4. Welding synergizing with both 3D metal laser and waterjet cutting for structures and tanks
5. Manual machining
6. Electronics lab reorganization and training
7. Autodesk Manufacturing Partnership (NDA signed)
8. CNC machining revolution – beginning at CAD/CAM and finishing with tooling (p10)
9. Remote operation technologies and practices (p11)
10. Professionalization, tracking and chemistry of cutting fluids
11. Serving students safely within COVID-19 controls (p12)
12. The Boilermakery founded this Fall funded by the Student Fees Advisory Board (SFAB)

Please read the pages of this report for the details of these incredible accomplishments, despite the staffing, budgetary and operational restrictions imposed by COVID-19. Keep in mind that Purdue student leadership and energy is responsible for these achievements – proof that if we give them the opportunities, they work miracles. I have every reason to be confident 2021 will be another giant leap.

Director

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SOCIAL MEDIA

Keep up to date with notable student projects and events from our social media:

1. Facebook facebook.com/PurdueBechtel/
2. Instagram instagram.com/purduebechtel/

INTRODUCING THE BECHTEL INNOVATION DESIGN CENTER

MISSION STATEMENT

We are a student-focused, peer-mentored, as-needed, educational community.

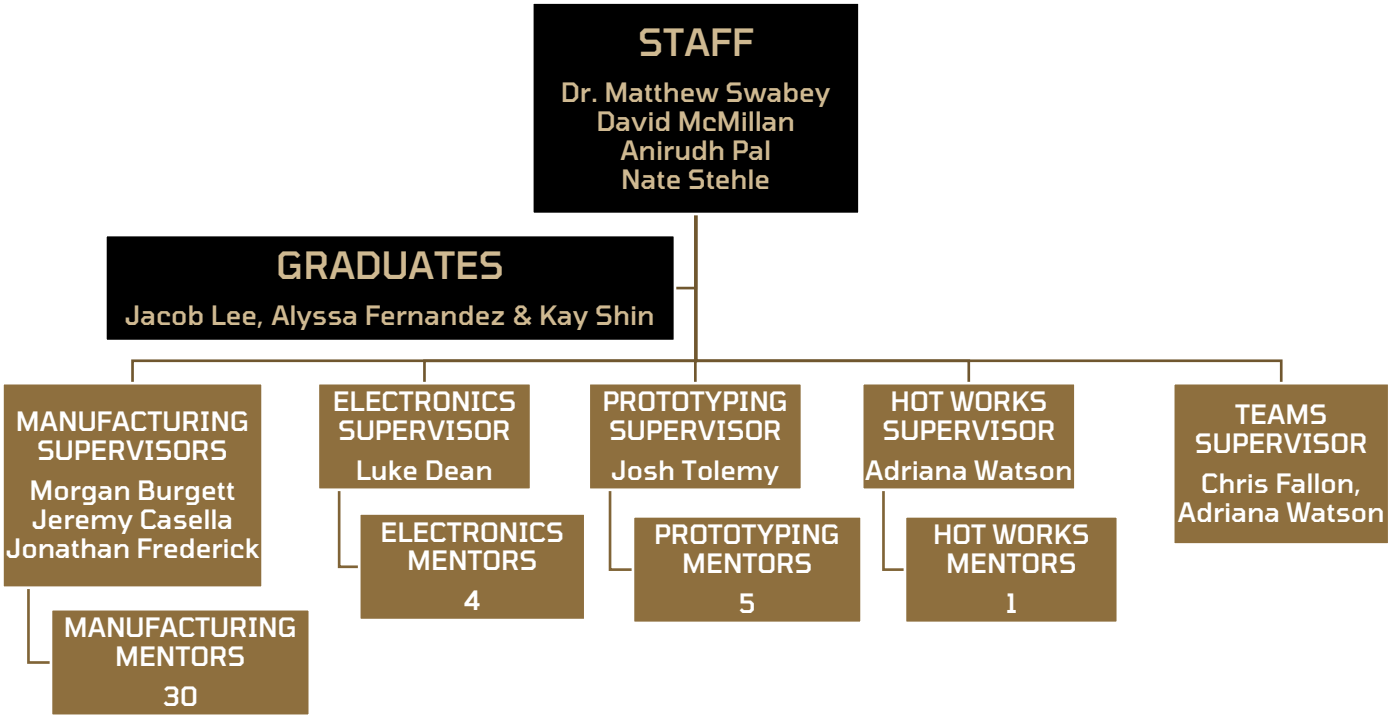
We provide the ability to complete projects through hands-on access to a safe ecosystem of consultation, training, technologies, and processes.

We support students that want experience, demonstrate ability, and have passion.

EDUCATION THROUGH OWNERSHIP

EDUCATION is challenging - the world of prototyping and manufacturing is vast, and every "rule" is "broken" in different circumstances. The Center addresses this by allocating the majority of our resources towards individualized hands-on training and support, empowering each student member to make safe and effective use of our growing library of processes.

OWNERSHIP is essential for education to take place. The Center is a place for the student member to capture the skills and knowledge and invest their time to progress their project. To be blunt, if the student does not capture or invest, their project does not progress. The Center strategy is to ensure bespoke training and support is available on a responsive, as-needed basis so whenever a student has time the Center is ready.



STUDENT LEADERSHIP AND OWNERSHIP

LEADERSHIP is responsible for creating and auditing our culture, driving innovation, increasing efficiency, and optimizing training. Undergraduate supervisors are technical experts in the processes in their area and are trained in interpersonal skills. In the dynamic environment of the Center, they oversee the training and growth of the peer mentors in their area as well as their timeliness and soft skills. Examples are recommending training, demonstrating novel concepts, professionalism, etc.

The “Active Student Employee Incentive Program” enables and rewards student employees that wish to acquire skills and grow towards leadership. The program funds, supplies, and provides mentoring to those employees who wish to go beyond their personal “comfort zone”.

OWNERSHIP is the driving force of accountability, and accountability is the defining characteristic of leadership. The Center grows leadership by entrusting students with genuine ownership over key areas of the Center and its operation, while mentoring them in an environment where failure is tolerated, out-of-the-box thinking encouraged, and mistakes valued and analyzed. Safety improvements, technical advances, progress, and mistakes are all part of the daily lives of our student leaders and student employees as they work tirelessly to improve the capabilities, accessibility, and availability of the Center to their peers.

Student employees (peer mentors) provide the first point of contact for student members who wish to use the advanced processes the Center makes available. Their typical role is:

1. Assess the student’s capabilities and their concept
2. Audit the safety of the manufacturing processes and the student’s training
3. Map the member concept onto capabilities available in the Center and advise on design changes
4. Demonstrate the processes and subsequently mentor the student in their application

TECHNICAL PROCESS LIBRARY

Manual milling & turning	Painting (paint booth)
CNC multi-axis milling & turning	Welding (TIG, MIG, stick, oxyacetylene)
CNC gantry machining for molds / wood	Metal braking/bending
Composite manufacture (carbon fiber pre-preg.)	Plasma cutting
Waterjet cutting	Soft materials and fabrics
Plastic, wood, fabric laser cutting	Battery manufacture and spot welding
Steel, aluminum sheet, and tube metal laser cutting	Electronics prototyping
3D plastic printing	Electronics assembly (SMT, through hole)
3D metal printing	IoT platform development
Powder coating	Testing facility (drones, limited energy release)
Metrology	

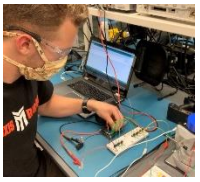
SPOTLIGHT: LEADERSHIP

"Having the opportunity to teach and meet so many people from the vast and diverse Purdue student body is the best part of my job. Every day I look forward to seeing the creativity and determination of my fellow students in successfully completing their projects."

Morgan Burgett, Manufacturing Supervisor, Agricultural Machine Systems Engineering

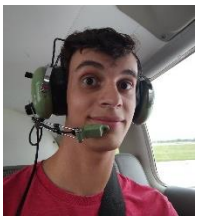
"As a Supervisor, I have had the opportunity to help lead the development of our processes and learn as I take risks and grow in knowledge and leadership. Working with students to help them grow in an understanding of manufacturing and design has proved invaluable. Working with such supportive industry partners provides an opportunity to learn from experts and make mistakes along the way in a safe environment."

Jeremy Casella, Manufacturing Supervisor, School of Aeronautics and Astronautics



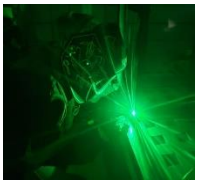
"The Bechtel Center has taught me that mistakes are integral to every great success. Its supportive policy on self-improvement has empowered me to grow into my potential and take the large risks that have helped me transform the electronics lab into the success it is today."

Luke Dean, Electronics Lab Supervisor, Electrical Engineering Technology



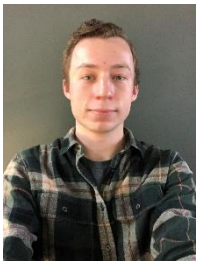
"Being a Supervisor at the Bechtel Center is a unique experience as I am not only a resource, helping facilitate other students' learning, but also learning myself. Technical parts of machining get easier with experience and a fundamental understanding of the work being done, beyond just using a machine. I have shared my experience with members and tried to give them the same appreciation for the fundamentals of design and manufacturing, especially the volunteers who will become peer mentors to continue the cycle. Everyone works differently, not only technically but also as a team, and working as a supervisor has given me experience and a better look at how members work and interact in such a dynamic environment."

Jonathan Friedrich, Manufacturing Supervisor, School of Aeronautics and Astronautics



"Being a supervisor at the Bechtel Center has allowed me to gain valuable experiences that I could not possibly have encountered in a class. While my day-to-day responsibilities may vary greatly, the one constant is the continued lessons in leadership that I have learned at the Bechtel Center. Thanks to the Center's unique environment that prioritizes learning and personal development over things like profit, I am able to truly lead my lab, as well as the subcommittees I have formed, and make decisions that genuinely impact both the employees that work in the lab and students who use the Center."

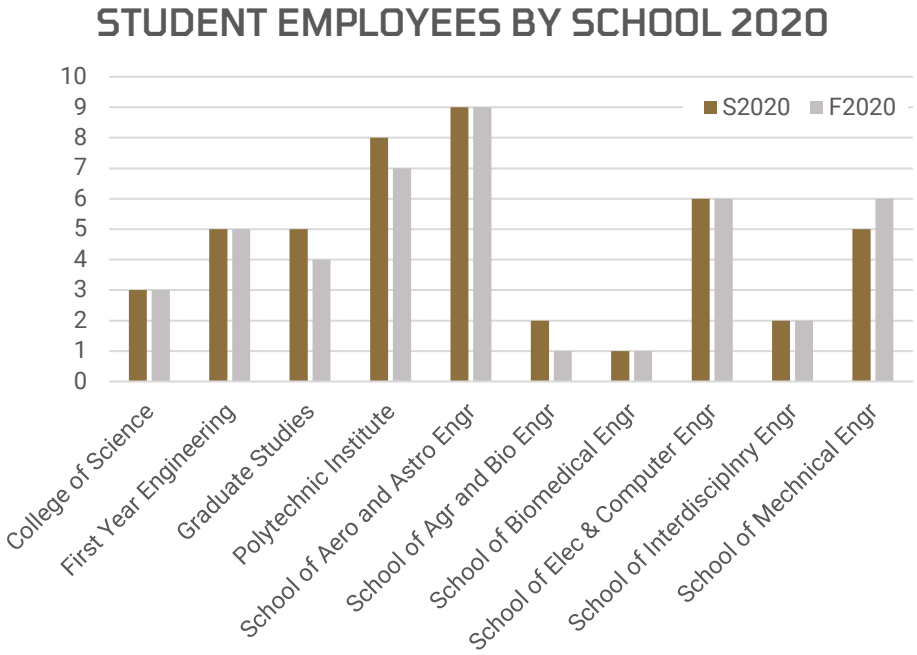
Adriana Watson, Hot Works Supervisor, Robotics Engineering Technology

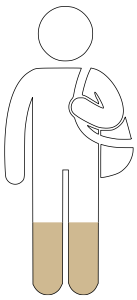


“During my time as Supervisor of Printing and Prototyping, I've had the opportunity to work more with Peer Mentors and student members in efforts to improve the lab and expand the variety of prototyping opportunities available. In pursuit of expanding upon these new opportunities, I have been able to engage more fully with the Center’s mission and develop my experiences with regard to leadership, education of others, and work and improvement within a technical environment. Above all else, the leadership opportunities provided to me as a Supervisor of the space have most notably allowed me to discover my passion for the educational process and the implementation of prototyping and engineering design processes in STEM which I am now pursuing for my master’s degree.”

Joshua Tolemy, Prototyping Supervisor, Mechanical Engineering Technology

STUDENT EMPLOYEES FACTS AND FIGURES





SPRING 2020 – 42 STUDENT EMPLOYEES

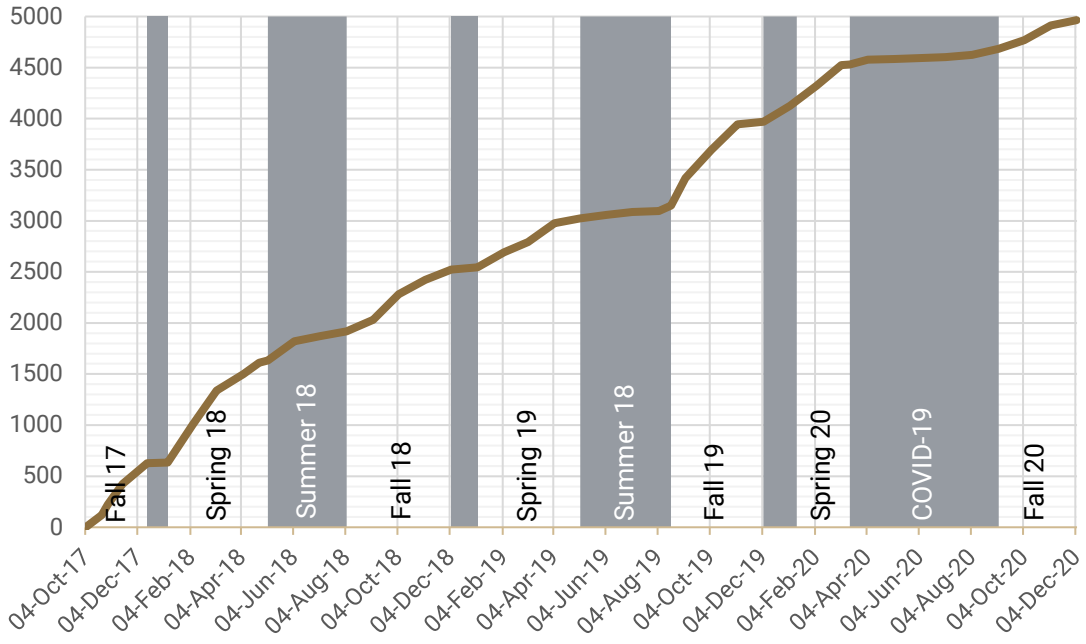
21% FEMALE, 79% MALE

FALL 2020 – 42 STUDENT EMPLOYEES

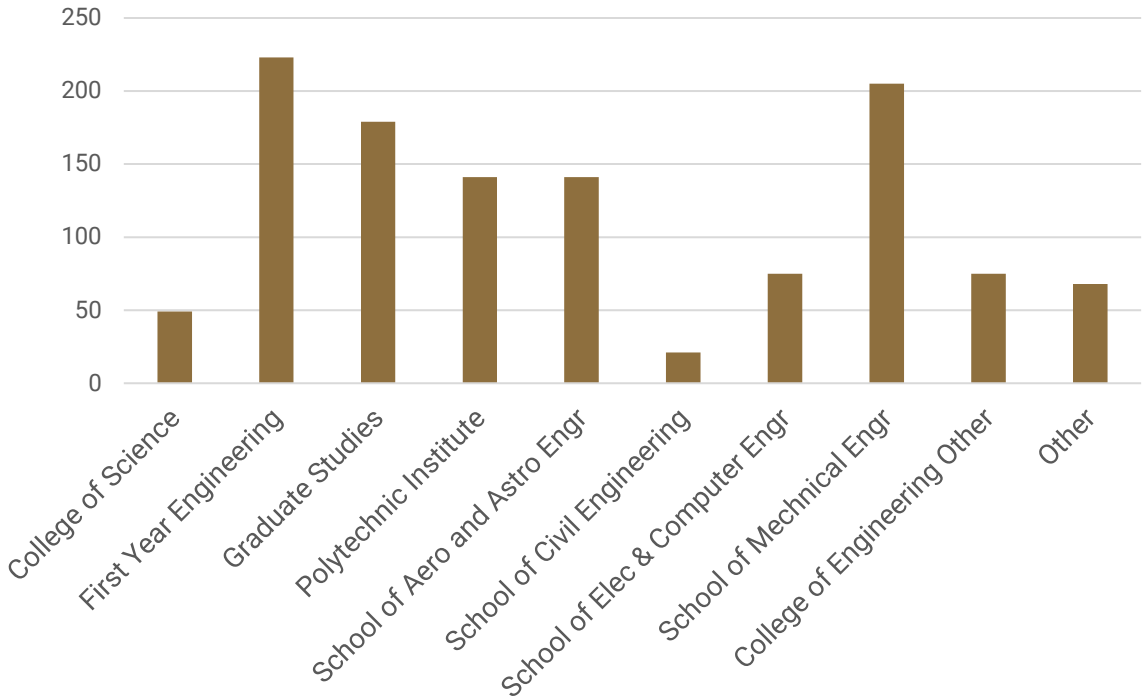
26% FEMALE, 74% MALE

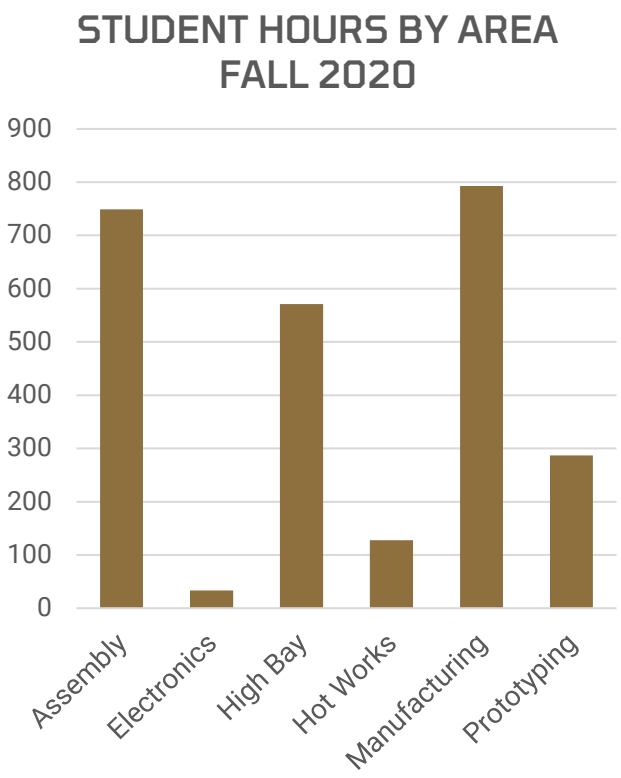
STUDENT MEMBERS OF THE BECHTEL CENTER

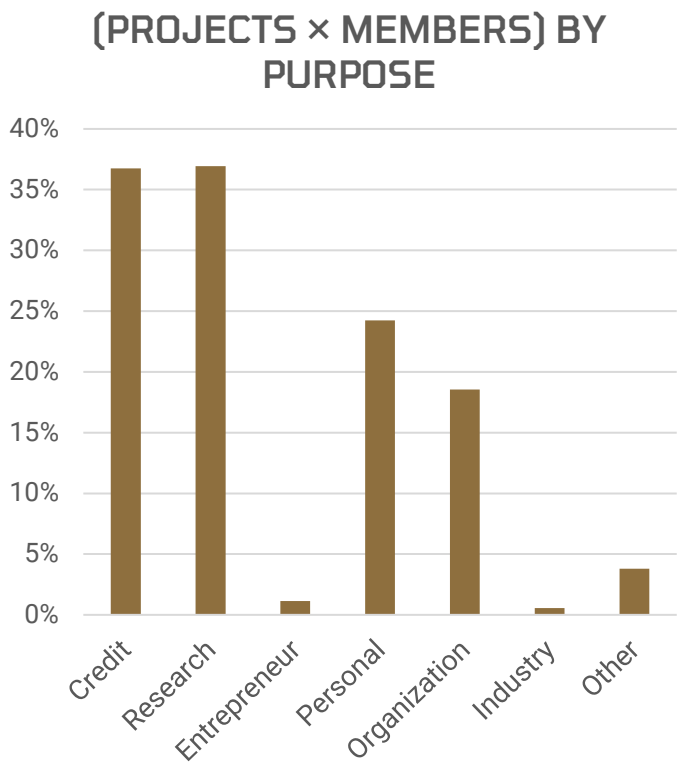
CUMULATIVE NEW STUDENT MEMBERS



NEW STUDENT MEMBERS BY SCHOOL 2020







MULTIDISCIPLINARY RESIDENT TEAMS

Certain student teams at Purdue benefit from a long-term grant of space in the Bechtel Center's assembly area. Our expectations of such teams are greater than for normal students as they are granted 24/7 access to limited capabilities / spaces in the Center.

- Preferably teams are multidisciplinary, featuring more than one Purdue School
- Teams appoint a safety manager who meets regularly as part of the team safety committee
- Teams may get approval to bring in specific additional tools/technologies they need
- Training on team specific resources / workshops are provided
- Teams consulted on new processes and operating procedures in the Center
- Regular reviews of the use of the space and center resources are conducted with staff

12 RESIDENT TEAMS WITH 189 ACTIVE MEMBERS

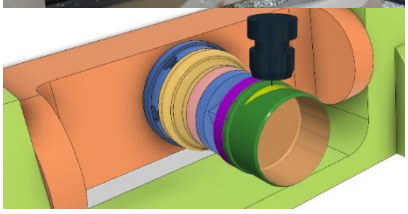
% OF TEAMS: NUMBER OF SCHOOLS REPRESENTED

50%: 3+ SCHOOLS INCLUDING COLLEGE OF ENGINEERING AND POLYTECHNIC

17%: COLLEGE OF ENGINEERING AND POLYTECHNIC

17%: 2 SCHOOLS INCLUDING COLLEGE OF ENGINEERING

SPOTLIGHT: EDUCATIONAL DIGITAL TWIN CNC PLATFORM



HTTPS://YOUTU.BE/WK2TNTFDRPM

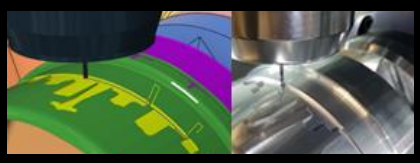
The full use of advanced modern manufacturing technologies is challenging in industry. The equipment is designed for full-time experienced designers and operators pumping out thousands of identical parts versus student projects requiring only a few different parts.

Created and maintained by Anirudh Pal and a growing team of over 19 students, our **EDUCATIONAL DIGITAL TWIN** provides Purdue students using the Gene Haas Manufacturing Lab access to advanced computer numerical control manufacturing machines along with the latest carbide tooling from Kennametal and modern fixturing from Raptor.

The **EDUCATIONAL DIGITAL TWIN** transparently packages thousands of hours of experience with the Center's tools, work holding, and machining parameters in a 1:1 design and simulation environment built on Autodesk's Fusion 360 cloud platform. It equips new users with experience normally gained through years of study, eliminating costly redesigns and crashes. In this environment users can design, innovate, and collaborate virtually, in their own time, wherever they are, before manufacturing in the Center.

The system is maintained by a very tight cloud-based knowledge dissemination loop. For example, in less than a day a new speed/feed for a specific material and tool will go from validation in the machine via the cloud to the hundreds of student designers.

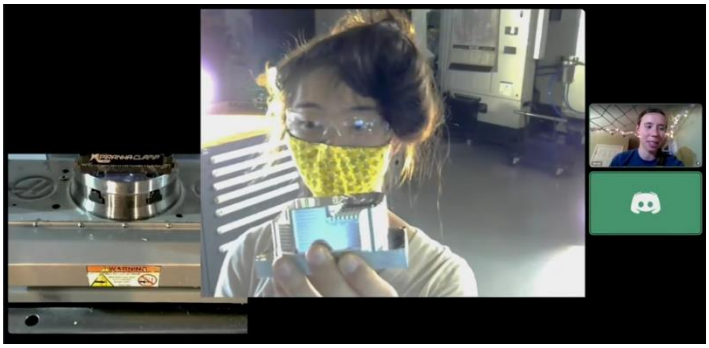
TRADITIONAL CNC	EDUCATIONAL DIGITAL TWIN
Optimized for part machining time	Optimized for CNC setup time
Disconnect between designer / operator	Unified flow from CAD–CAM–CNC machining
Limited 2D/3D modelling and animation of process	1:1 3D animation of tool, stock, and work-holding
Only models the tool and stock for collisions	Holistically models the CNC, the work-holding, the tool body, the tool, and the stock
Work holding has to be modelled	40+ pre-validated work holding configs provided
Manually driven probing w. risk of probe crash	Automated probing from CAM eliminates errors
Major cause of damage: tool collisions with part, with work holding or speeds/feeds errors	Collisions detected in CAM software before machining, known good speeds/feeds provided
Knowledge of the 130-key CNC control required	Only 3 keys of the CNC control used
Tool parameters & probing must be keyed into the CNC control (5+ menus +100s of key presses)	Tool parameters & probing automated, errors will be detected. Video prompts, load tool, hit START
Tool building knowledge required	Standardized tool building with template aids
CNC tool loading knowledge required	Specific tool loading demonstration video plays on control at appropriate moment
Personal knowledge of speeds/feeds/tools	Constantly updated cloud with 172 tools and 335 validated speeds and feeds



5 – AXIS CNC SETUP AND TOOLING TIME FOR AN EXPERIENCED EMPLOYEE REDUCED FROM 90 MINUTES TO 30 MINUTES

SPOTLIGHT: REMOTE MACHINING SERVICE

In response to COVID-19 we were able to pivot off the success of the Educational Digital Twin platform to layer live video and audio streaming as well as screensharing of the CNC control and CAD/CAM computer desktop to build an integrated environment where a remote student can observe and guide the manufacturing of their part in real-time with the local assistance of a Bechtel Center peer mentor.



1 https://youtu.be/s9J71QO4UwE

The remote student is able to choose between:

1. The CNC control screen
2. Video from inside the CNC
3. Mobile camera for viewing stock, tool building, and the supporting mentor

During the process constant communication is happening between the mentor and student.

SPOTLIGHT: WORKSHOPS

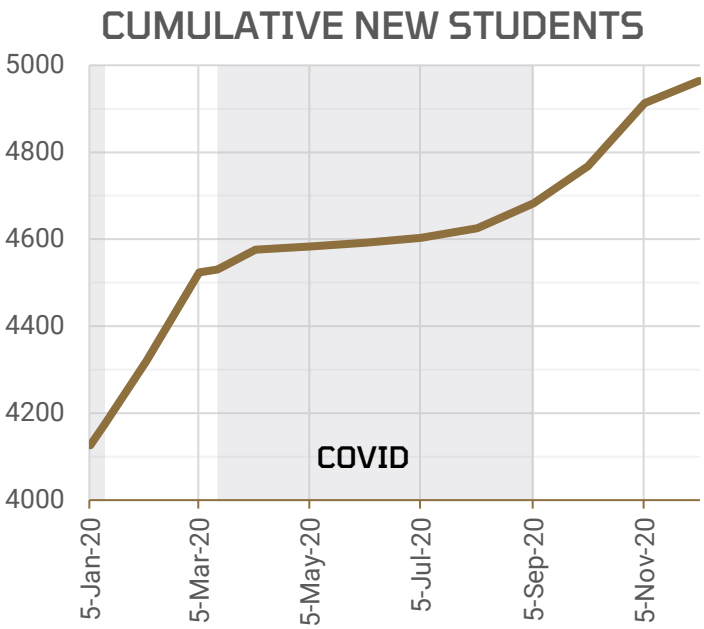
In addition to being responsive to student member needs, the Center has begun a workshop program around selected Artisanal skills. These skills are characterized by a need for a certain amount of dexterity and experience. Providing them as-needed has been challenging so a workshop program consisting of part classroom theory and part hands-on skills development/practice sessions has been developed to address it. The program began with welding/hot works led by Adriana Watson.

Building on this foundation, we plan to expand workshop offerings in a variety of areas such as electronics and jewelry making where pilots have already started.

SPOTLIGHT: COVID-19 CONTRIBUTIONS

COVID-19 brought challenges to everyone, both personal and professional. By leveraging our strong student leadership and flexible approach, the Bechtel Center was able to:

1. Reopen safely to students as soon as possible - 28/28 independent snap audits passed without fault in 2020
2. Create an unparalleled remote machining experience built on our EDUCATIONAL DIGITAL TWIN platform
3. Produced >30,000 COVID-19 PPE parts
4. Reverse engineered, redesigned, and developed manufacturing for seven ventilators parts



When campus went remote beginning in early March 2020, the Center immediately began an intensive series of strategy meetings with our teams and student leader stakeholders to position the Center to reopen safely and securely as soon as possible. In that time, we were a founder member of the PPE manufacturing effort. During the summer, Dr. Swabey reviewed over 50 COVID-19 SOPs for four buildings on campus (EE, Bechtel Center, KNOY, and MSEE). This was both to ensure that campus' return to research proceeded and to gain the essential knowledge and networking to ensure the Center was able to re-open.

COVID-19 SAFE REOPENING

The Center successfully reopened at the beginning of fall, with the full 2020 count of new student members hitting 800+, and passing 28 of 28 independent snap inspections of COVID SOPs without comment.

By making Purdue students integral to the planning and decision-making process, they became a key part of the solution, self-policing and exercising responsible judgement.

COVID-19 PPE PRODUCTION – MEDICAL SUPPLIES RESPONSE TEAM

As a founding member of the Purdue COVID-19 Medical Supplies Response Team, the Center produced >30,000 COVID-19 PPE parts. In parallel, David McMillan and others also reverse engineered and redesigned seven different ventilator parts for hospitals in Indiana that had become impossible to source commercially due to supply chain collapse.

Additionally, David McMillan and Dr. Matthew Swabey designed and produced a custom tube cutting machine that was built in a few weeks to supplement the PPE production effort. It was able to cut 120 pieces of tubing a minute to the correct length, freeing a team of volunteers to focus on other aspects of PPE production.

INDUSTRY PARTNER UPDATE

Kennametal is a world leading metal cutting tooling designer and manufacturer. It focusses on supporting users of its products in order to be successful. Kennametal is one of the Center's primary supporters supplying Purdue Students with both expertise and the latest in metal cutting and shaping tools.

Autodesk makes software for people who make things. The educational digital twin would not be possible without Autodesk as a partner. The Bechtel Center staff are able to participate in the internal discussions of Autodesk's Manufacturing Team under NDA, bringing pre-release and advanced technologies to Purdue students.

Haas Automation Inc. and the Gene Haas Foundation (GHF) have been an amazing partner since the founding of the Bechtel Center. Supplying both the CNC technologies (Haas) and funding for students to focus on CNC skill capture (GHF), they have enabled generations of students to learn about and enjoy high tech manufacturing.

Raptor work-holding produces world leading fixtures. In machining, a leading problem is workholding that holds the metal stock repeatably and securely, enabling rapid multi-axis machining. Raptor supports the students by making their advanced technologies available to Purdue Students.

Master Fluid Solutions is an American family-owned business. Advanced industrial fluids in the form of coolants, cutting lubricants, and other advanced mixtures are an essential part of advanced manufacturing. Master Fluid solutions supports the students with chemical assays, advanced cleaners, coolants, tapping fluids, and their industrial expertise.

CAMPUS IMPACT

The work of the Bechtel Center is visible throughout Purdue. Student members and their projects alongside student staff and professional staff are a foundation of the promotion and recruitment materials of the Purdue Polytechnic Institute, School of Mechanical Engineering, School of Aeronautics and Astronautics, School of Electrical and Computer Engineering, Computer Science, the annual reports of the Office of Professional Practice, and multiple times in the College of Engineering.

2020 - 36 CLASSES IMPACTED

AAE450 AAE451 AAE490 AAE535 AD215 CNIT17600 CSR328 ECE362 ECE477 ECE49022 ECET270 ENGR16100 ENGR10300 ENGR10301 ENGR131 ENGR162 ENGT18000 ENGT481 ME263 ME315 ME444 ME463 ME498 ME588 MET111 MET211 MET213 MET401 MET402 MET451 MET482 MSE430 MSE499 NUCL325 TECH120

OUR STAFF

DIRECTOR MATTHEW SWABEY

Dr. Swabey oversees Center strategy, fundraising and mentors the student leadership. In addition, he provides leadership, training, education, and support for students working on both curricular and extracurricular projects in the facility. Matthew also engages in the development of policies and procedures, constantly improving and seeking ongoing frictionless operation of the facility.

ASSISTANT DIRECTOR DAVID MCMILLAN

As Assistant Director of the Bechtel Innovation Design Center, David researches and develops new processes, educates and trains our student leadership. In addition, he oversees safety, operations, and maintenance in the Center. Engaging with students and vesting responsibility with them is a key part of the Center's success.

COMMUNITY COORDINATOR NATHAN STEHLE

Nathan is responsible for managing student interaction with the facility and its full time and student employees. He is also the party primarily responsible for driving and tracking student project work as well as all related data gathering. Nathan serves as the go-to contact point for project design and review and is responsible for determining final project approval status.

TECHNICAL OPERATION MANAGER ANIRUDH PAL

Anirudh is one of the key cogs in the innovation machine of the Center. He attained a Master of Science in the field of Computer Science at Purdue and has held multiple positions at the Center as a student employee. The intersection between his academic experience and passion for machining leads to operational changes that utilize software to simplify the daily operations of the Center and its members.