

EMBRACING DIGITAL DENTISTRY

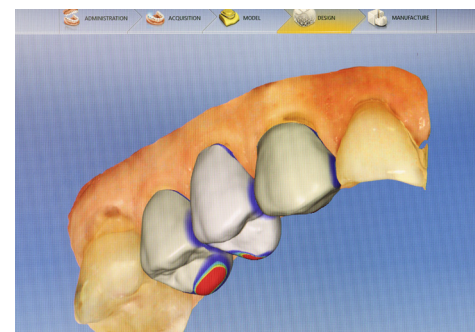
TWO NEW STATE-OF-THE-ART CENTERS INTEGRATING DIGITAL CAPABILITIES, DELIVERING CUTTING-EDGE TRAINING AND PATIENT CARE

To train dental professionals who will be leaders in their respective fields in years to come, their education needs to encompass the techniques and technology that are on the verge of transforming the profession. Enter the ever-growing advances in digital dentistry, and to that end, Penn Dental Medicine's Digital Innovation Initiative — aimed at fully integrating the latest in digital dental technologies at almost every stage of education and patient care.

OPPOSITE: The resources of the new Digital Design and Milling Center (top) and the Center for Virtual Treatment Planning (bottom) represent the culmination of the School's Digital Innovation Initiative.

Two gleaming new spaces in the lower level of the School's Thomas Evans Building opened earlier this year and mark an evolution toward embracing digital dentistry and digital workflow across the School. With state-of-the-art equipment, the new Digital Design and Milling Center and the Center for Virtual Treatment Planning, together with new staff and curriculum changes, represent a culmination of the School's Digital Innovation Initiative, opening up new possibilities for training students, conducting research and continuing education, and delivering seamless and cutting-edge patient care.

"The many types of digital technologies working together is the key to effective application and outcomes in patient care and education and that is our goal," says



Dr. Markus Blatz, Professor and Chair of Preventive and Restorative Sciences and Assistant Dean for Digital Innovation and Professional Development, who has championed and led the School's Digital Innovation Initiative.

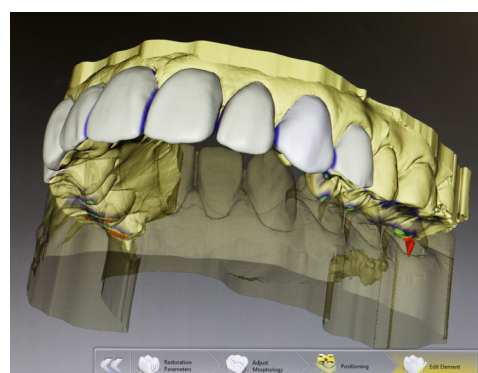
"The stage of taking a digital impression and fabricating a restoration are at the end of the game, but there are additional technologies that help us right from the beginning — in treatment planning, in face scanning, with electronic health records. All this information interconnects, and this, I think, is one of the big advantages of digital dentistry."

BUILDING A DIGITAL DESIGN TEAM

Ever since joining Penn Dental Medicine's faculty in 2006, Blatz has worked to integrate digital technologies into many aspects of the School's operations, notably in his areas of expertise: materials science, prosthodontics, and esthetic dentistry.

Recruiting expert faculty was a key part of this effort. In 2008, Michael Bergler, who trained in Germany, joined the School, bringing with him many years of education and practice as a master dental technician with extensive experience in both traditional laboratory methods as well as CAD/CAM (computer aided-design and computer-aided manufacture) technology.

"My philosophy in life is that you can either go against the technology, and say,



"It's rewarding to see where we are today with intraoral scanners in all our clinics and the many resources of our new Digital Design and Milling Center."

- DR. JULIAN CONEJO

'I don't want to have anything to do with it,' or you can make yourself an expert and try to get as much knowledge as you can. This is what I did, because I saw such a big opportunity in doing so," says Bergler, who is currently pursuing a Master of Science in Digital Technology to stay on top of the latest developments. "I'm highly motivated to share my experience with students and faculty."

Together, Blatz and Bergler built the Penn Dental Medicine CAD/CAM Ceramic Center, formerly located on the third floor of the Evans Building, (and now evolving into the Center for Virtual Treatment Planning) to enhance the School's digital competencies in research, education, and clinical care. For the last dozen years, the facility has been involved in every level of digital technology development and a centerpiece of materials research, complex esthetic case design, and

related software development. "This lab built the foundation for the new Center for Virtual Treatment Planning," said Bergler, Director of the CAD/CAM Ceramic Center.

Meanwhile, five years ago, Blatz recruited Dr. Julian Conejo, Clinical CAD/CAM Director, a prosthodontist who had been using digital technologies in his own private practice since 2010, to continue to enhance the Penn Dental Medicine community's

digital expertise. Conejo's focus was in furthering research in these efforts, particularly in chairside CAD/CAM dentistry. With Blatz, he began a pilot study to test a fully digital workflow, using one intraoral scanner and one milling machine, Conejo personally assisting each student who wanted to complete a fully digital case. Quickly, the pilot proved to be a success.

"We were quickly able to ramp up that pilot study to a bigger scale," says Conejo. "And now, it's rewarding to see where we are today with intraoral scanners in all our clinics and the many resources of our new Digital Design and Milling Center."

Upon arriving at Penn Dental Medicine in 2018, Dean Mark Wolff also recognized the importance of training dental students in digital dentistry and embraced and bolstered their efforts to continue to move the School's Digital Innovation Initiative forward, fast-tracking plans to create these new facilities.



TOP: Dr. Markus Blatz with a student in the Digital Design and Milling Center, which features 12 PCs loaded with three types of design software for different applications.

OPPOSITE: The Center is equipped with 10 high-speed milling machines for producing restorations that range from one to eight units; Dr. Julian Conejo milling a restoration with a student (bottom). Soo Ann (top, left) works with a student to fire and finish a restoration; there are eight ceramic furnaces in the Center.

NEW DIGITAL HUBS

Those plans became a reality this year when the two adjacent spaces opened — the Digital Design and Milling Center, with a focus on chairside CAD/CAM applications and headed by Conejo, and the Center for Virtual Treatment Planning, led by Bergler and addressing complex cases and full-mouth restorations. Both spaces are outfitted with state-of-the-art equipment and technology and came together in part through generous in-kind support from corporate partners.

The Digital Design and Milling Center features 12 computers/design PCs loaded with three types of software for different applications: one for designing and milling single-unit restorations like inlays, crowns, and veneers; another for implant-related restorations and surgical planning; and a third laboratory-oriented program for digital wax-ups. Students can 3D print models from the digital wax-up at Penn's Biomedical Library free of charge, but soon there will be 3D printing capabilities at the School as well.

In addition, ten high-speed milling machines line one wall of the Center, producing restorations that range from one to eight units, and there are also eight ceramic furnaces for firing and finishing restorations.

Full-time dental technician Soo Ann, who joined the School in June, manages daily operations in the Center. Students are assigned a PC where they can pull up their patients' digital scans, and then, Ann supervises the design milling process. Second-year prosthodontics residents also do a rotation in the Center once a week, assisting DMD students with their cases.

"The residents are a great asset," says Conejo, "for they learn as well by teaching and getting more hands-on in the lab."

Centralizing the entire design and production process in the Center, as opposed to dispersing design software and milling units across the School's clinics, ensures better quality control and helps Conejo and others track trends, such as which cases are being addressed digitally most often, and what materials are most popular.



A goal of Conejo's is for the School to eventually be alginate-free, referring to the material typically used to make dental impressions. With 17 intraoral optical scanners now dispersed throughout the School's clinics, the School is moving in that direction. A top priority has been to significantly increase the number of scanners to ensure all students and faculty across clinical departments are able to apply this technology to patient care.

"Our faculty and students have been trained to use this technology," says Conejo, "and I foresee that in the next couple of years we'd be doing 100% digital impressions."

Along with being more comfortable for patients, Conejo explains that digital impressions have a host of benefits over traditional ones. "The scanning process is fast, it provides files that can be easily shared among specialists or a dental lab, and if needed, part of the mouth can be quickly reimaged," he



says, "while if a portion of a traditional impression comes out faulty, the entire process needs to be repeated."

Incorporating digital design files into a patient's electronic health records also then ensures that an identical restoration could be replicated if needed in the future, making work flow much more reliable.

With the digital transformations, information technology needs are changing as well. Sam Bogharas was hired two years ago to ensure that IT issues were being met, including aspects related to patient privacy and adhering to best practices for digital storage. The Center is also reaching across clinical departments at the School. "Our goal is to strengthen and support all departments with digital cases and applications," says Conejo. "And to use the resources of the Center to train other clinicians as well through hands-on continuing education."





“This can give the patient more security in going through the treatment,” says Bergler.

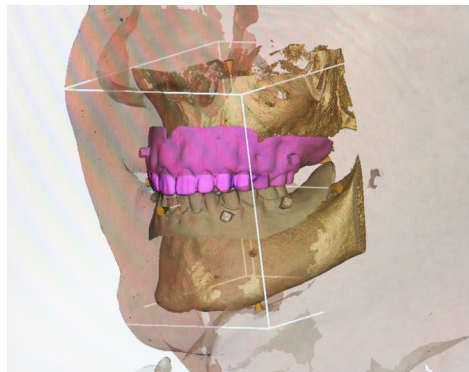
In terms of production technology for executing treatment plans, the Center features three industrial five-axis milling machines that can mill a full spectrum of materials, building residents' understanding of the milling process as well.

The Center's design and production capabilities also allow research to be conducted under controlled circumstances, evaluating how a particular intervention went, and evaluating new materials and technologies. One area of recent research is 3D printing oxide ceramics, a technology Bergler believes could hold promise for the future. “We get very valuable data out of our work that we're able to give back to industry,” Bergler

For cases that require more complex planning, next door is the Center for Virtual Treatment Planning. The vision for this new facility is to educate, train, and support postdoctoral students in digital case set-up and give them the opportunity to use the latest software tools for virtual treatment planning. The Center's six work stations are outfitted with a full spectrum of digital technology for planning implant- or tooth-supported restorations.

“We have a total of 24 licenses of professional 3D designing software,” says Bergler, “and each one has over 50 designing tools — from digital denture set up and an implant planner to wax-up and model creators, just to name a few. It is important that residents understand how different digital tools interact with each other and see the impact they have on the success of a restoration.”

However, the centerpiece of the new center is the newly developed virtual treatment planning software — features of which were developed in conjunction with the School's CAD/CAM Ceramic Center to establish digital wax-ups in a timely and predictable way. Bergler explains that files can easily be interchanged with other software for smooth and predictable workflow. The software's newly developed tools include digital tooth extraction, digital pontic design, and face morphing to simulate face and jaw movements in real time.



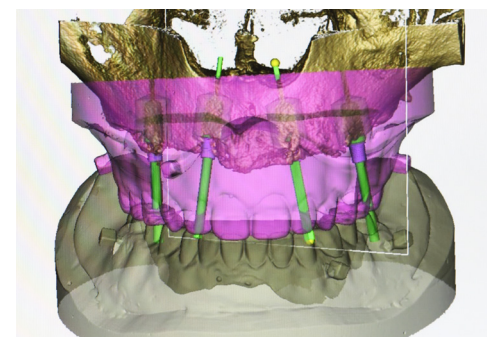
“Based on the huge amount of data we can collect via scans, we are able to create a virtual patient on screen...and most importantly, simulate different treatment options.”

— MICHAEL BERGLER

The driving concept Bergler developed for the Center is focused on creating “a virtual patient.” “Based on the huge amount of data we can collect via an intraoral and/or laboratory scanner, a [cone beam tomography] scan, a face scan, we are able to create a virtual patient on screen,” he says. “Residents can basically superimpose all of these data sets, and then most importantly, simulate different treatment protocols for their particular cases.”

In addition to helping residents learn in a more comprehensive fashion, the sophisticated combination of technology helps patients directly, too. Clinicians can develop personalized approaches, and show them to the patient in advance, allowing them to offer feedback to shape the clinician's vision.

says, “in order for them to make changes and improve CAD/CAM systems and materials for better patient care.”



TOP: Michael Bergler working with a prosthodontics resident on a case in the Center for Virtual Treatment Planning. The design stations are outfitted with 24 licenses of professional 3D designing software.

OPPOSITE: Residents working on treatment planning.

AN EDUCATION FOR THE FUTURE

While many long-established private practices may not yet embrace digital dentistry, it's clear that it's the way of the future, and as part of the Digital Innovation Initiative, both the predoctoral and postdoctoral curriculum has been adjusted to incorporate experience with CAD/CAM technology. Presently, DMD students are required to do two completely digital cases, but Conejo anticipates that now with the additional resources in the Digital Design and Milling Center that may increase. Bergler's changes for the curriculum aim to prepare the residents for an independent and confident handling of complex digital planning.

"We have seen students heavily engaged," says Blatz. "They're digital natives



and are eager to engage with these new technologies."

Even first- and second-year students are now learning to use intraoral scanners in the preclinical simulation labs, scanning mannequin mouths as they simulate procedures to begin refining their techniques before entering the clinic. By the time students reach their third and fourth year, they'll be ready to apply these techniques in patient care. For postdoctoral students, too, digital design enables entirely new ways of approaching challenging cases.

"Our Center for Virtual Treatment Planning has a huge effect on the quality of our teaching," says Bergler. "Our residents are able to simulate a variety of treatment

protocols without even touching a patient, which is giving them detailed impressions about the opportunities and impacts of digital technologies in dentistry. This is making their learning experience much greater."

Conejo is also working on an e-book to serve as an on-the-go reference for students and faculty as they prepare to use this in their everyday patient care.

Students on the cusp of entering the workforce feel they are gaining invaluable experience working in the Digital Design and Milling Center. Aledy Moreta Abreu (D'20), a fourth-year DMD student, says she's gained the hands-on knowledge in her time working with digital technologies at Penn to feel confident about eventually employing them in a career as a general dentist.

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- DR. MARKUS BLATZ

"In the past, you would take an impression for the patient, send it to the lab and they would take care of everything," she says. "With digital scanning and design, we're involved in every step."

William Kessler (D'20), another fourth-year DMD student, had the opportunity to work on a case with Conejo and Bergler, addressing a gap between the patient's front teeth and replacing an existing crown on one of the front teeth at the same time with two preparations designed to match perfectly. Conejo, Bergler and Kessler documented the case and Kessler presented it at the Society for Color and Appearance in Dentistry meeting in September 2019, winning first place in the clinical case report competition.

"This was definitely one of the highlights of my time here," Kessler says. "Everyone went so above and beyond to allow me to learn something I had not encountered before."

RELENTLESS IMPROVEMENT

As anyone who has owned a laptop or cell phone knows, digital technologies are not static; they're constantly evolving. To ensure that the technological resources and techniques on which Penn Dental Medicine depends are the best available, faculty and students are engaged in research projects to identify best practices and provide feedback to industry partners to continue refining their products.

"We're doing studies on some of the new materials, on 3D-printed materials, and we've done retrospective studies to see what is working best for our patients," says Blatz. "We work across the board with dental manufacturers, because they trust us to give them unbiased feedback about their materials and equipment."

In the future, faculty envision every patient coming through patient admissions at the School to be scanned, and Blatz foresees more and more restorations being manufactured in-house.

"We're now up over 50% of all the indirect restorations being done in house," Blatz says. "The Center's only been open a few months. It's far exceeded my expectations."

And though some may believe that a greater use of technology means less personal care, Blatz underscores that quite the opposite is the case.

"Some people think that with CAD/CAM technologies, everyone is getting the same smile, but in fact we can individualize care like never before by using scan files of natural dentition to design and restore teeth and smiles," he says. "With costs coming down and these technologies becoming more accessible, my hope is that ultimately, dentists are going to be able to provide more and more patients with customized restorations that look nice, that are well-fitting, and that have quality materials. That is the goal." ■

- By Katherine Unger Baillie