Education in a Remote World: Focus on Workforce Readiness

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Bucks County Community College (Bucks) in collaboration with Drexel University (Drexel) is committed to increasing the number of workforce ready engineers and engineering technicians and to creating a blueprint for 2+2 engineering education programs nationally. Recently, educational reform took an unexpected turn to remote teaching due to the world-wide COVID-19 pandemic. Within our NSF ATE grant to enhance our present engineering technology curriculum we modified and enhanced instructional and student engagement methods to assure workforce readiness of our students in a remote world. Curriculum enhancements within the engineering technology (ET) occupational major at Bucks and the B.S. in ET degree program at Drexel, modifications to delivery of workforce development certification programs through the Bucks Center for Workforce Development (CWD), and college-wide student engagement strategies were implemented to assure quality education and student engagement. Modifications to credit courses included asynchronous online courses, synchronous remote courses, and hybrid courses, which combined remote and on campus laboratory instruction. Our CWD implemented hybrid instruction that included necessary resources for students such as tool kits and borrowed laptop computers. In addition, a college wide program called Bucks+ was implemented through the Bucks Business and Innovation Department to increase enrollment, retention, and workforce readiness of students. The Bucks+ program focuses on student engagement through competition within curriculum, and extracurricular endeavors that prepare students for industry. We will share our successes and challenges within our call to action to engage students in a remote world and to enhance their educational experience through innovative instructional techniques.

As K-12 schools, colleges and universities abruptly shut down in early March of 2020 due to the unexpected and rapid onset of the COVID-19 pandemic, educators and administrators had to quickly plan to continue instruction from a widely different perspective. Bucks County Community College (Bucks) and Drexel University (Drexel) implemented engagement strategies such as synchronous remote teaching, asynchronous online teaching, hybrid instruction, and college-wide engagement strategies that helped to seal the educational gap created by the unexpected and immediate closure of our institutions [1], [2]. Funds from our NSF ATE Grant #1902075 in collaboration with Drexel: *Increasing the Number of Workforce-Ready Engineering Technicians in Southeastern Pennsylvania,* helped Bucks to pave the way for innovation in technician education through a formalized connection of our credit and non-credit sides of the college, and by enhancing the curriculum for technician education (Figure 1).

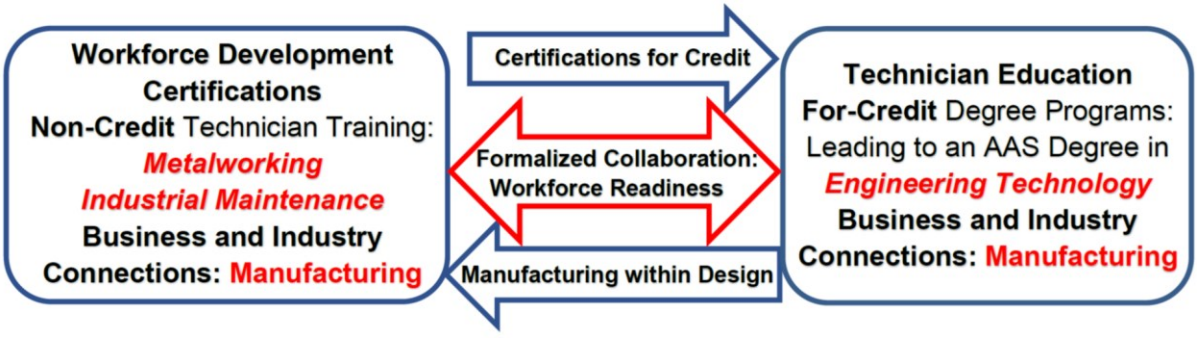

Figure 1. The formalized collaboration of the Bucks credit and non-credit sides of the college.

Within the goals of the grant to enhance the workforce readiness of our students, Bucks formally connected the engineering technology major to the Center for Workforce Development (CWD) by accepting certifications for college credit [3], [4]. During the pandemic, as part of enhancing curriculum to accommodate the college closures, techniques to engage and to retain students were developed within the credit side, the non-credit side, and through College-wide engagement initiatives sponsored by the Bucks Business and Innovation Department (Figure 2). These techniques and strategies that were developed to enhance curriculum to best serve the students during this unprecedented time are expected to become a blueprint for the future of education.

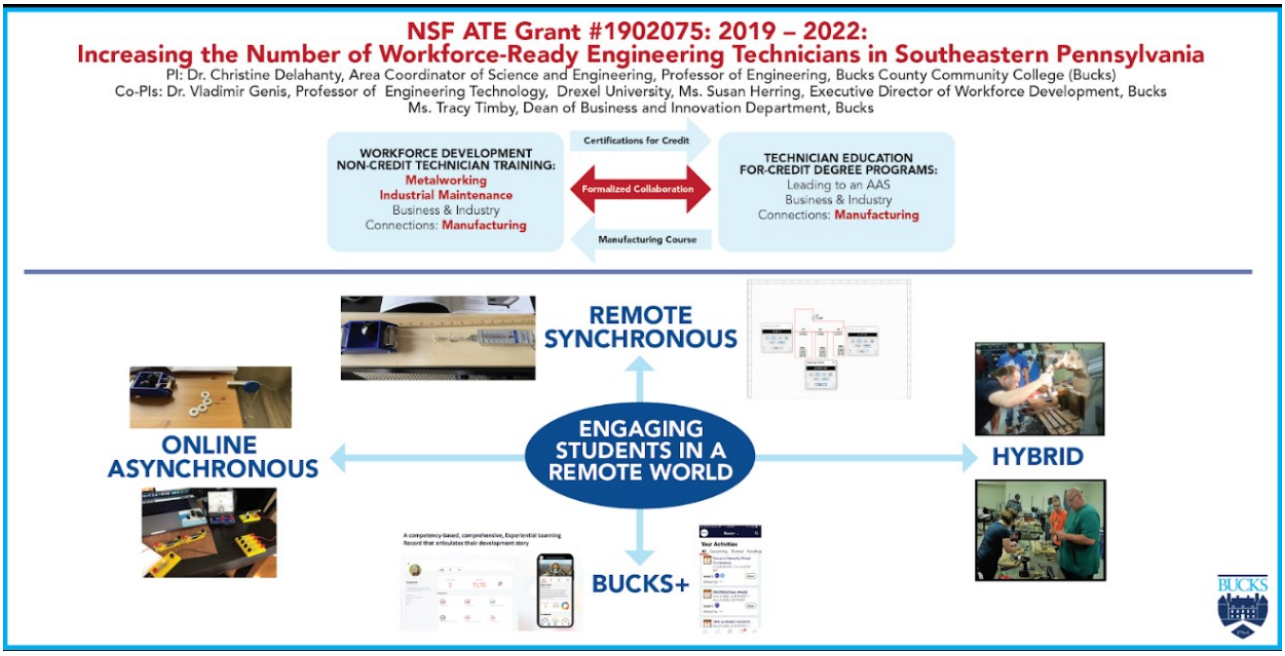

Figure 2. Strategies for teaching and engaging students during a pandemic.

Conducting courses within the credit side of Bucks and Drexel consisted of continuing once face to face classes in a remote setting. Educating engineering and engineering technology students became particularly challenging within some courses, as laboratory moved from on campus to in the home. Hybrid instruction for other courses within both the credit and non-credit sides of the college allowed for students to come to campus safely, with social distancing and personal protective equipment (PPE), to work with instrumentation and to complete their experiments. The College also assured the safety of the faculty and students by carefully assessing every room for the number of people that would be feasible with social distancing, and with providing a protocol for attendance on campus. The College also provided hand sanitizer,

additional cleaning supplies, and PPE for anyone who needed to come to campus, including students, faculty, and staff.

Due to the shortage of PPE supplies and equipment during the pandemic, and delayed delivery of many necessary supplies, the engineering area at Bucks manufactured 3D printed frames and laser cut shields, and 3D printed stacks of straps for masks for students who attended the hybrid courses (Figure 3). This effort required very careful planning with respect to not only designing stacked supplies for 3D printing for laser cutting, but also of protocol with respect to coming to campus to use the equipment during the pandemic. Techniques and lessons learned from this real-world, very challenging PPE effort at Bucks will be further developed and utilized within engineering and engineering technology curricula to promote workforce readiness.

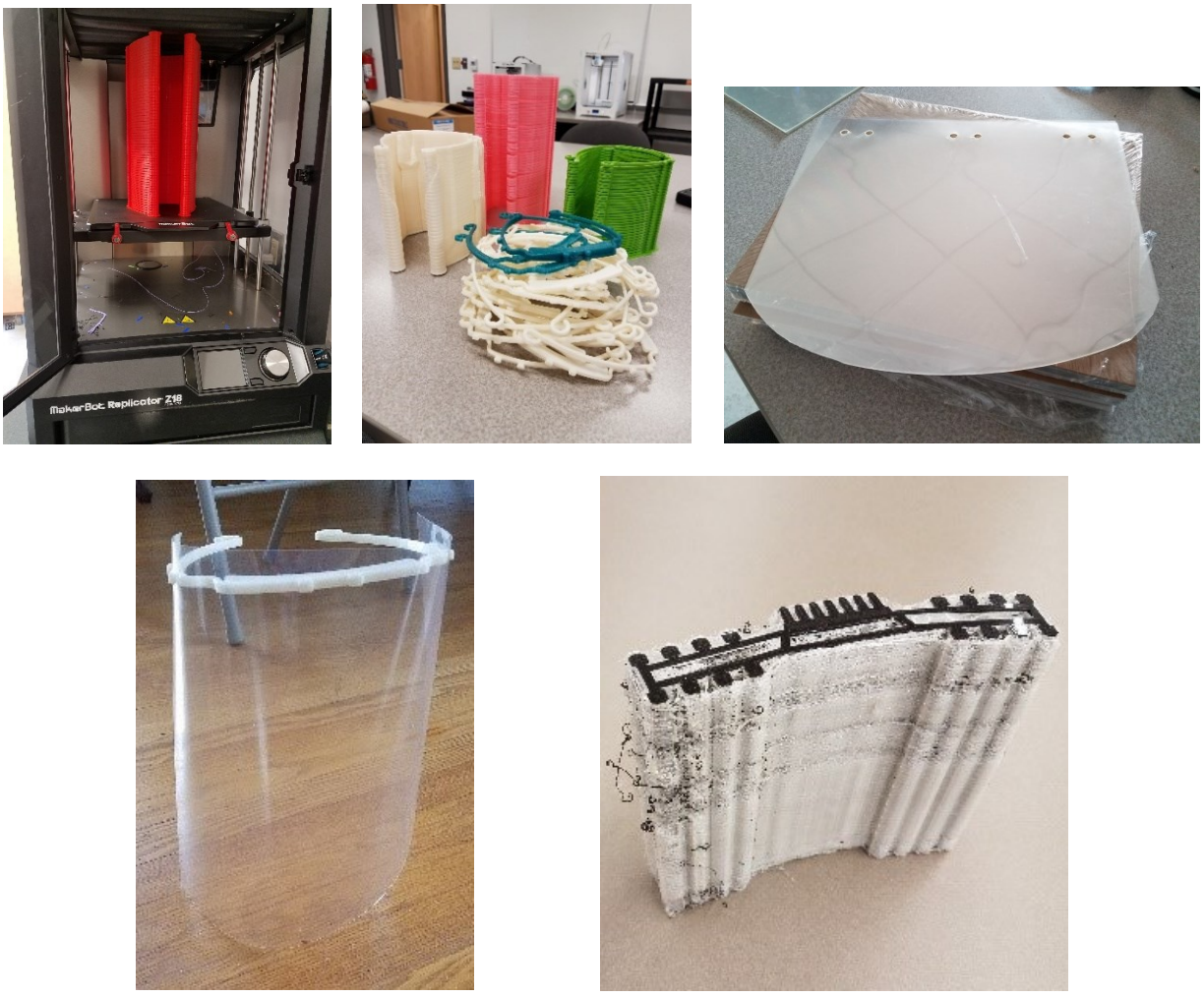

Figure 3. Stacks of 3D printed PPE frames, laser cut face shields to attach to the frames, and straps for face masks were manufactured in house at Bucks, and distributed to students and faculty in hybrid courses for additional safety.

At Bucks, switching from face to face teaching to remote teaching was easier in courses, such as physics, that already utilized an online modality, with hands-on at home labs using kits. Bucks was voted the #1 online community College in Pennsylvania in 2020, and has a long history of quality online learning [5]. Instructional techniques applied to online courses already in place, we utilized in the switch to remote teaching for the courses that started the spring term as face to face. The College assured that the faculty had ongoing opportunities for professional development during the spring 2020 term, throughout the summer before fall classes began, and during the fall term. Faculty were also provided access to online resources that allowed them to become more proficient with newer instructional techniques and technologies. They were also introduced to instructional resources that could become part of their canvas classroom for effective remote teaching, and for students to use within assignments.

Hands-on experiments that had to now be completed at home, had already been utilized in the online courses, and were easily adapted to courses in a remote setting. In addition, online tools such as Multisim™ and MATLAB™ allowed students to create computer simulations of experiments that they could analyze and report on. The simulations coupled with the laboratory kits provided an excellent laboratory experience for the students (Figure 4). This method of coupling simulations with at home and hybrid laboratory experiences, was adapted for physics, engineering, and engineering technology courses, in addition to other STEM courses. Some of the instructors at Bucks and at Drexel recorded laboratory experiments, where they discussed collected data as part of their Zoom™ classroom. This allowed students to observe the experiments in a lab setting in a synchronous setting with the instructor explaining details of the experiment. Students were then expected to analyze the data provided from the experiment, and compare it to the concepts learned in class. Some instructors utilized data analysis software free to the students through the College, such as PASCO Capstone™, and many continued to incorporate Open Educational Resources (OER) into their Canvas™ course spaces, for both laboratory and lecture, as free engagement, and instructional tools.

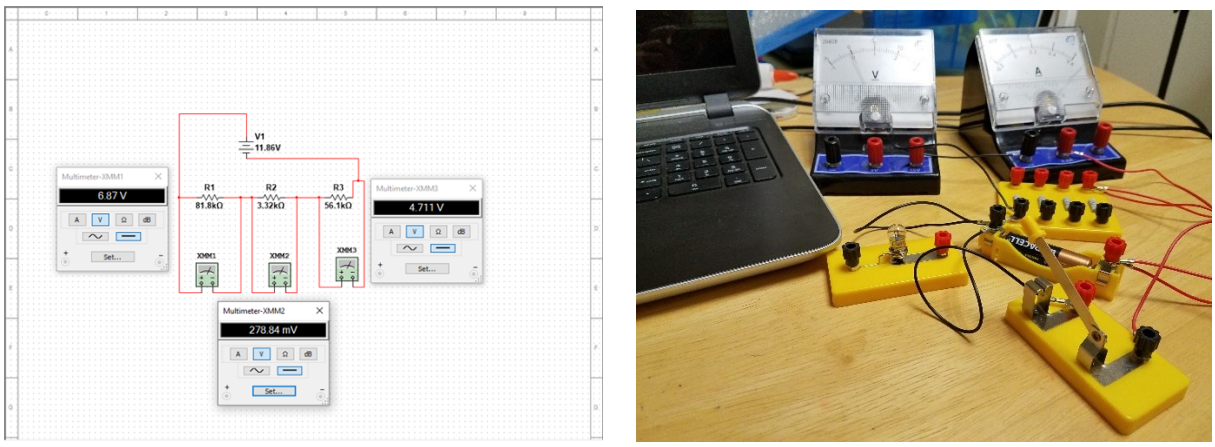

Figure 4. Simulated circuit designed using Multisim, and circuit constructed from a kit for physics and engineering technology courses.

Lab kits for both mechanical and electrical courses provided excellent hands-on experiences for students at home (Figures 4 and 5). Discussion Boards within the Canvas platform for each lab exercise allowed students to communicate and collaborate similar to a face to face lab setting. The College provided necessary resources to students in need such as computers and lab kits. Companies provided free software to students as well during the shutdown, which made the transition from face to face to remote teaching even smoother. At Bucks, our laboratory assistant prepared a collection of tutorial videos on how to use the various measuring devices that were in the laboratory, and how to conduct the experiments. These videos were used for all modes of course delivery, including remote, online, and hybrid instruction. Students in the hybrid courses were able to view the instructional videos before coming to lab. Students in the online and remote courses were able to view the tutorial videos as an enhancement to the devices that were part of their lab kits. These videos proved to be excellent instructional tools for all modes of course delivery.

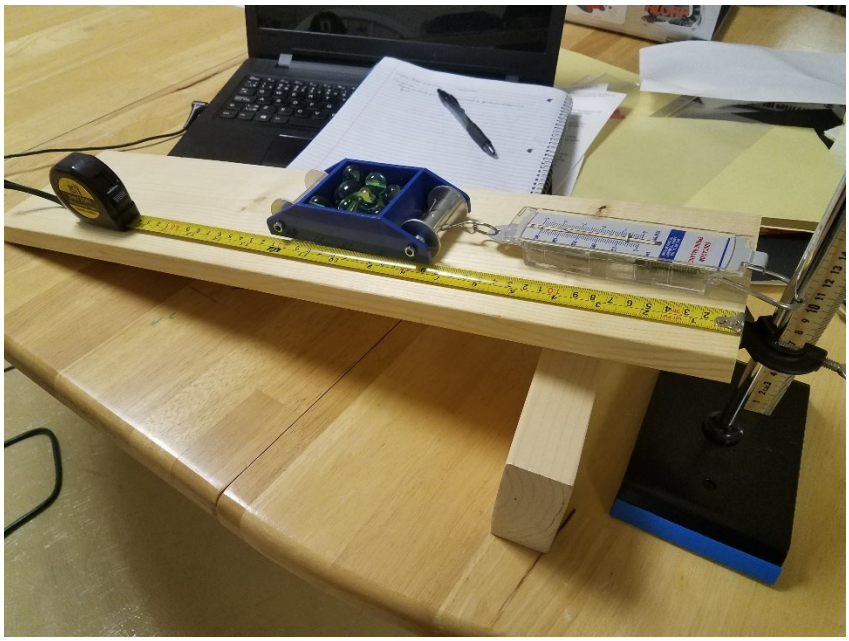

Figure 5. At-home apparatus for hands-on physics mechanics lab.

Other enhancements to remote classes included in depth discussions during the Zoom sessions, and question and answer sessions, to assure that students remained connected to the classroom and continued to learn the concepts. Communication was determined to play a very important role in retaining students, and creating an atmosphere that was conducive to success. Graded Discussion Boards within the Canvas courses played a great role in creating a classroom atmosphere, and in assuring students that they were not alone (Figure 6). Students worked

together, communicating within the many discussions, related to both homework and to laboratory. This helped to establish a community within the remote and online settings, leading to increased retention, and ultimately to success in the courses. Some instructors created smaller groups of students for discussions and utilized the breakout rooms within Canvas to work on class problems and experiments together. Faculty were reminded that some students may not have the necessary capability to maximize their experience such as video on their computer, and faculty had to adjust their teaching methods and requirements when necessary. Students who had little, or no capability were loaned computers through Bucks. This was on an as needed basis, and proved to be successful during the emergency.

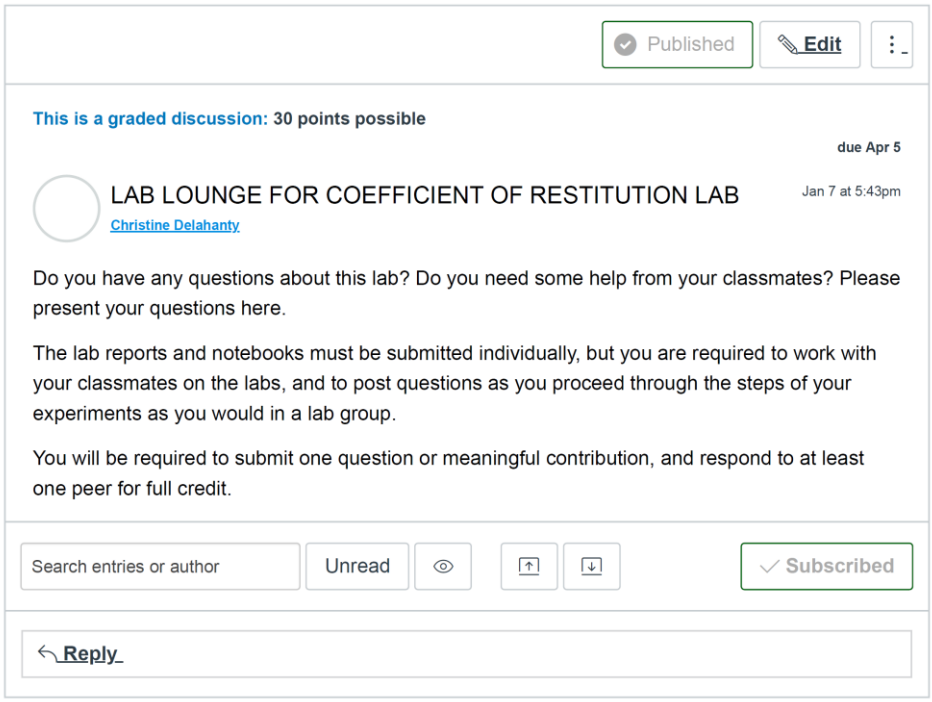

Figure 6. Graded Discussion Board on Canvas where students were required to discuss a physics lab, and collaborate on procedure and results, for class credit.

Online, audio/visual presentations as assignments in physics and engineering courses involving special topics, open ended investigations, and case studies, proved to be a great success. Encouraging students to be creative, and to apply innovative thinking in their investigation, and in their presentation was the key [6], [7], [8]. In our engineering statics and strength of material courses, which were conducted in a synchronous, remote setting, students chose an engineering disaster or innovation to present to the class via a live five minute Power Point presentation (Figure 7). A five minute presentation with a maximum number of slides allowed, was appropriate for keeping the class engaged, and for keeping the scope of the project

and presentation reasonable. Since students were able to choose their own topic to investigate, they were very interested to present their discoveries, ideas, and solutions. Students decided how to present the problem, which had to relate to concepts learned in class, the engineering reason for the disaster or the poor design, and possible innovative solutions. Students were excited about choosing and researching their own topic, and their fellow classmates asked excellent questions during the live Zoom session. In online physics courses, students were required to post an audio/visual presentation to a Discussion Board, and respond to each other's presentations asynchronously. This approach to our asynchronous, online courses also proved to be very successful in engaging students. This was accomplished through requiring students to participate in a question and answer session via the Discussion Board.

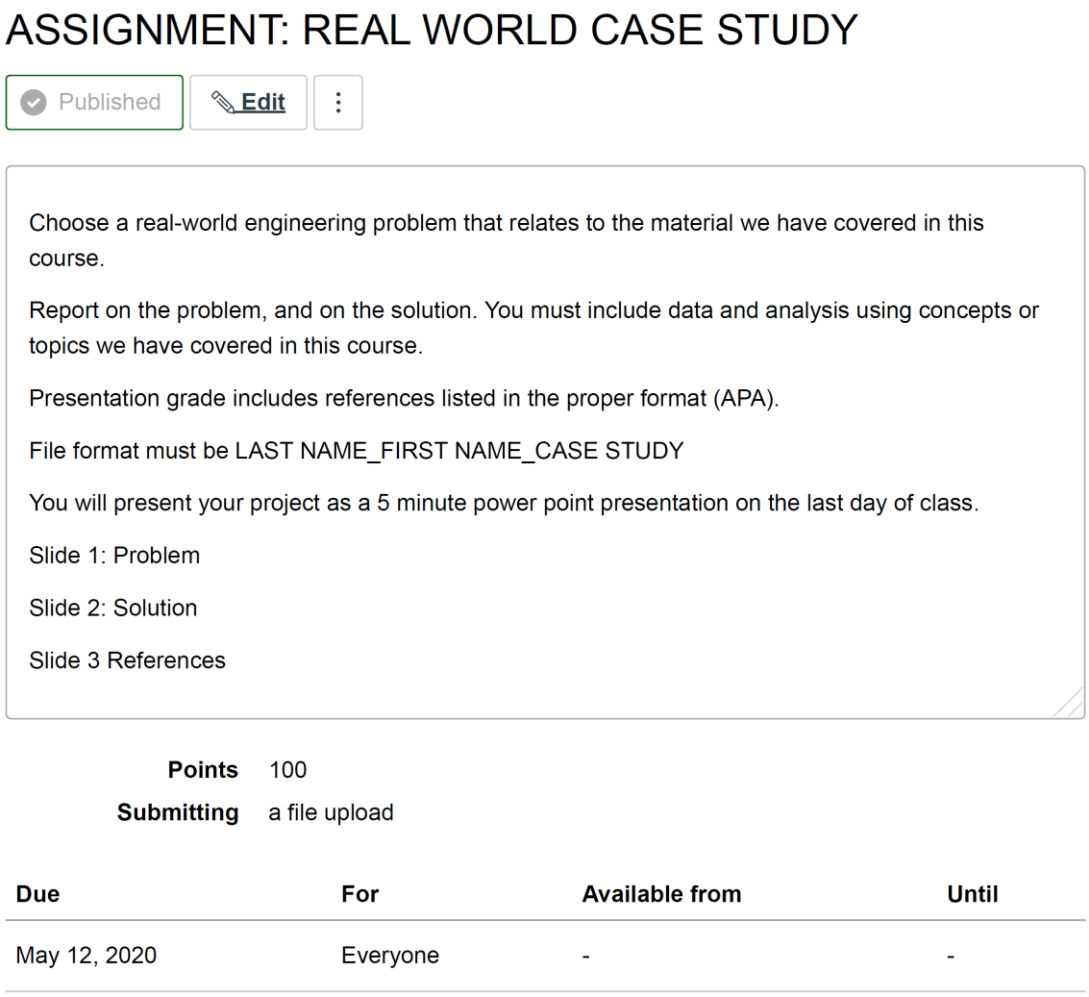

Figure 7. Case study assignment on Canvas that required students to investigate and report on a real-world engineering problem.

Monitoring exams became a challenge in the rapid switch from Face to face to remote teaching, and faculty had to develop strategies for accommodating exam time. College campuses, and proctoring sites used for monitored testing were shut down, and faculty had to think quickly. Some offered timed exams during synchronous class time, others offered a timed exam in Canvas that could be completed within a window, and some used Proctor U™, an online proctored testing site. Instructors also used Turnitin™ for monitoring the written word in laboratory assignments, and students were reminded of the College's Academic Integrity Policy to help curb plagiarism and other forms of cheating. In addition, faculty shared experiences, ideas, and strategies with each other during department meetings, and professional development sessions, which helped to maintain a level of consistency with administering the assessments.

Bucks updated the remote format of the courses for our spring 2021 term at the discretion of the professor, to include an option of a mix of synchronous Zoom sessions and asynchronous delivery through Canvas. This addition, as a variation of the fully synchronous remote delivery, added a level of flexibility for the students, which encouraged increased engagement. After the designated Zoom instructional session, which was shorter than for the fully remote format, students were provided additional independent work, example problems, and assignments, that they were to discuss with one another via the discussion boards. Breaking up instructional class time via Zoom to include engagement activities in addition to straight lecture, was determined to be a factor in maintaining student interest and focus [9]. This mixed option proved to keep students more engaged in some courses where the total instructional minutes for each class was longer. The multiple delivery options are being used in the Spring and Fall 2021 terms, and will also be considered for the Spring 2022 term depending on the College protocol in place due to the pandemic.

Communication to help engage and retain students was not restricted to the classroom, and cultivating workforce readiness was multifaceted. Students who needed tutoring could seek extra help with their course work in the virtual Bucks Academic Success Center [10]. The STEM Department also provided additional faculty assistance in their virtual STEM Learning Center (SLC). Full and part time faculty were available at scheduled times to provide extra help in all of the STEM subjects such as math, chemistry, biology, physics, computer science, and engineering. Faulty instructors were provided with schedules for both the Academic Success Center and for the SLC, and students could make appointments with tutors to meet for a Zoom session, or drop into a faculty tutor's already scheduled session.

Advising was shown to play a major role in retaining students because it helped to assure that students chose the appropriate classes to streamline completion [9], [11], [12], [13], [14]. Bucks recently enhanced their advising process, and continued to advise students through the pandemic. Mandatory advising at Bucks via email, Zoom, and phone, assured that students received the proper guidance as they chose their classes, planned for subsequent semesters, and for transfer to four year institutions. Trained faculty advisors and professional advisors hired by Bucks specifically for this purpose, worked together to address unique student needs and situations [15]. Effective communication contributed to the effectiveness of the advising effort, where advisors corresponded with each other regularly via email, with questions regarding particular students, and at Zoom meetings with ideas and strategies for enhancing the student experience. Career and mental health counseling was also shown to be very important in retaining students [11], and particularly important during the pandemic. Virtual counseling

services were available to students through the Bucks Center for Career Employment & Career Development, and through Counseling Services, so that students could address and communicate career or mental health concerns due to additional pressures they experienced during this unprecedented time [15], [17]. Faculty were reminded to include access to these valuable remote services in their Canvas course spaces, and to further communicate via Canvas announcements, the availability of these additional services to students.

The non-credit side of Bucks was faced with a particular challenge due to the extensive hands-on training that students in workforce development programs needed to complete their certification programs. The Center for Workforce Development (CWD) offers two pre-apprenticeship programs that provide students with industry recognized credentials and prepare them for good-paying careers in manufacturing [18]. Over the past few years, these programs have been instrumental in feeding much needed entry-level workers into machine operator and electro-mechanical technician careers.

Figure 8. Students wearing PPE while working with equipment during on campus portion of hybrid course for CWD Metalworking Pre-apprenticeship program.

CWD's employer partnership includes over 70 manufacturing companies such as KVI, Inc., Jade Medical, Double H Plastics, Macron Dynamics, Specialty Ring Products, White Engineering, Laboratory Testing, and Northtec/Estee Lauder. Most of these companies remained open as essential businesses during the pandemic. Their need for new talent remained constant,

even when most employers were scaling back. Therefore, when the quarantine hit, it was important for the pre-apprenticeship programs to continue. A major challenge of course delivery for the metalworking and industrial maintenance certification programs during the pandemic was the need to switch from exclusively face to face instruction to a hybrid format that included a combination of remote and in-class instruction. Careful planning was crucial to assuring that these students received the same quality of education regardless of modality (Figures 8 and 9).

Figure 9. Students wearing PPE while working with equipment during on campus portion of hybrid course for CWD Industrial Maintenance Pre-apprenticeship program.

Instruction very quickly transitioned from an intensive 6 hours per day, 4 days per week in-person schedule, to a 5 day per week hybrid format, with a shortened instructional day for online Zoom sessions. Students were loaned laptops, loaded with the AutoCAD™ software needed for classwork, and they receive a toolbox of hand tools and measuring devices, such as micrometers, rulers, tape measures, compasses, and calipers, to assist in building their hands-on skills while at home (Figure 10). Instructors used GoPro™ cameras to record sessions for those students who had to miss in-person class due to quarantine. Other changes had to happen with respect to company tours, which were an important component of the training. These tours couldn't continue in-person because industry partners were not allowing visitors on-site. As a solution, the CWD staff worked with company representatives to provide virtual tours of manufacturing facilities, with interactive question and answer periods built-in.

Pre-apprenticeship instruction continues to be delivered in a hybrid format, 2 days online, 3 days in the shop (Figures 8 and 9). The CWD certification program continues to be highly successful, where over 90% of graduates are placed into good paying jobs, even with the shift to hybrid instruction. Feedback from employers highlighting hired graduates of our CWD programs has continued to be very favorable. At our most recent Manufacturing Roundtable Meeting held in Winter of 2021, industry leaders were asked the general question, "What have been your top 3 challenges with attracting, hiring, and keeping talent?" Although major concerns were "lack of work ethic/habitually late or absent" (85%) and "can't find qualified candidates" for their companies (77%), one employer stated that students hired from the Bucks CWD certification programs remained on the job and were very reliable. Another employer indicated that with the strict CWD vetting process and continuous monitoring of student performance during the training sessions, it was "like having a 12 week vetting process" before the CWD graduates entered the workforce. Employers have expressed continued confidence that they are hiring quality personnel from our Metalworking and Industrial Maintenance pre-apprenticeship programs. This has given Bucks confidence that course delivery using different modalities produces the same high quality, workforce ready employee.

Figure 10. Tools and supplies issued to students in the CWD pre-apprenticeship programs for the at home portion of their hybrid certification course.

A College-wide initiative at Bucks to promote student engagement and cultivate workforce readiness implemented in 2019, proved to be an excellent mechanism for engaging and retaining students during this time. Bucks + is a co-curricular engagement program designed to increase workforce readiness, where students download the Suitable app on their cell phones and compete for points (Figure 11). It is designed to help students find and participate in

activities happening virtually, on-campus, throughout Bucks County, and within additional settings in the community [19]. It has been adapted as part of our College Readiness Seminar (COLL101), and is being introduced to faculty as a way to engage students within their classroom. As part of our enhanced engineering technology major, this College Readiness Seminar will consist of a cohort of engineering an engineering technology students, taught by engineering faculty. In addition to career exploration opportunities specific to these majors, such as company tours in collaboration with our CWD, these students will be required to participate in Bucks + activities as part of their professional development.

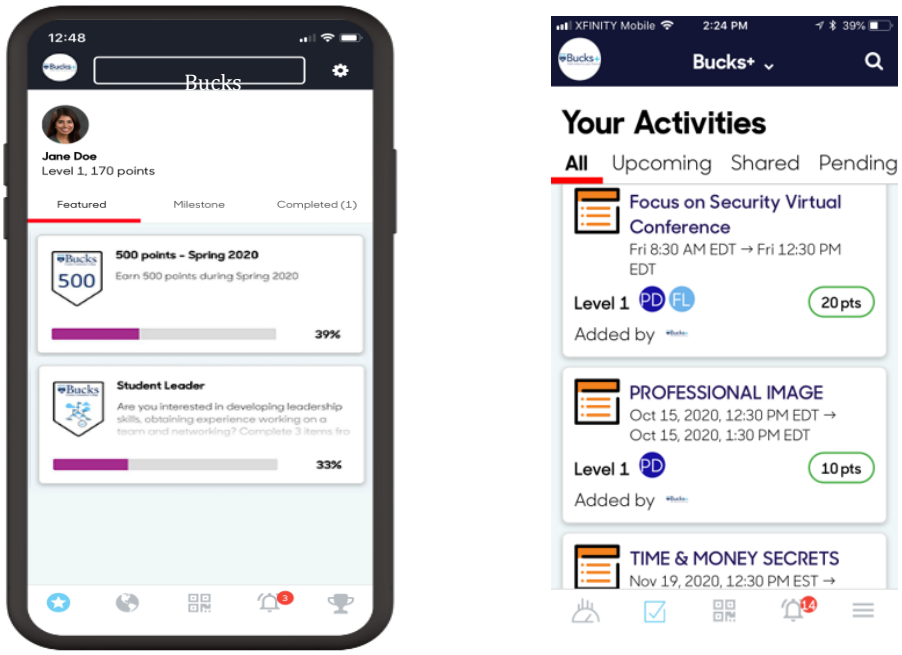

Figure 11. Cell phone with Suitable app installed and Bucks + appears to students.

An introduction to Bucks + is listed on its website, where "students earn [Bucks +] points for activities, event attendance, and accomplishments at varying levels. The program focuses on competency areas employers are looking for: Community Engagement, Financial Literacy, Global Awareness, Personal/Professional Development and Bucks Pride. Community Engagement activities encourage students to interact with groups and members of the community. This cultivates collaboration, networking, and teamwork. The Financial Literacy competency area allows students to become more financially aware, and to gain a better understanding of various financial areas. The Global and Cultural Awareness competency area provides opportunities for students increase their cultural awareness respect, and understanding of diverse cultures. Personal and Professional Development focuses on personal growth that will lead to students becoming more confident in themselves, and a better employee. Students track

their progress and share their accolades with peers, advisors, and employers using Suitable, an impact measurement tool for academic institutions.

Bucks+ was originally adopted by the Business + Innovation Department and is modeled after Temple University's recently developed Fox Leadership Development Program (FLDP) [20]. This program is a graduation requirement for Temple's Business School. Students must earn 1000 points (250 points per year) by attending or participating in extra-curricular/co-curricular events designed to enhance student skills (Figure 11)." [19] All of these competency areas are aligned with our NSF grant goals. As part of our enhancement to curriculum, the Bucks college readiness course will become specific to a cohort of engineering and engineering technology majors. In addition to participating in course requirements that will promote workforce readiness such as career exploration specific to engineering and engineering technology, company tours, and resume writing, this cohort will have the benefit of participating in Bucks + as part of the course.

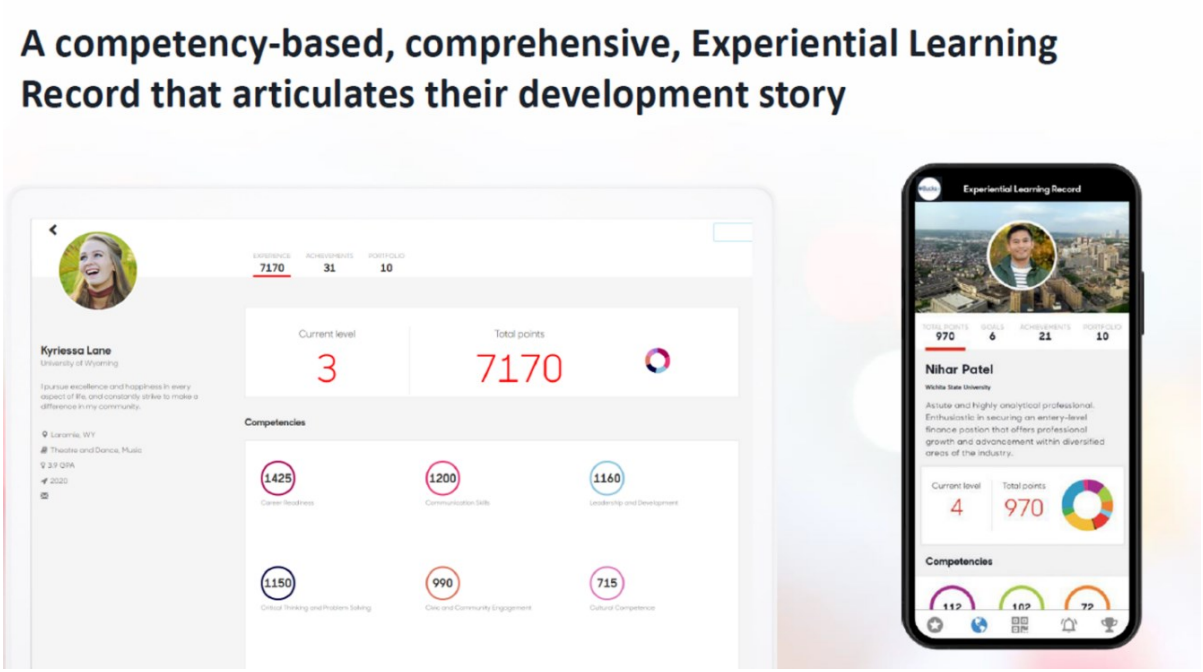

Figure 12. Description of Bucks + showing Leaderboard, and how it appears on a cell phone.

Drexel experienced its own unique set of challenges during the pandemic and the University wide shut down and had to switch from face to face teaching to remote teaching. Very tight restrictions on campus limited access to facilities. Additional material was developed for conducting real-time remote instruction of the courses that did not have laboratory components. Laboratory procedures of several courses, such as DC and AC circuit analysis, were carried out

using educational kits for simulation of laboratory experiments. For other classes, such as EET 333 (Nondestructive evaluation of Materials), real-time remote control of ultrasonic flaw detectors (USN 60 and USN 58L) was developed. During laboratory sessions, students could control flaw detectors remotely via computers. A remote connection to the USN 58L and USN 60 could be established by accessing the flaw detectors under the LabVIEW™ [21]. All commands performed by the USN 58L and USN 60 correspond to similar commands performed under LabVIEW™ control from the remote computer (Figure 13).

Students could remotely control and change any setting of the flaw detectors, such as calibration of flaw detectors and evaluation of the test objects and participate in the laboratory activities. Results of the calibration and testing could be saved from both local and remote computers. Unfortunately, during this academic year laboratory access was restricted and remote procedures could not be performed, since instructor's, technician's, or teaching assistant's presence at the local site is required for initial set-up of the videoconferencing and NDE equipment and handling of the transducers. However, work is continuing to create an environment where students will be able to have access to these devices in a remote setting. The state-of-the-art NDE facility will also serve working individuals interested in improving their skills in NDE, as well as those seeking knowledge for professional advancement.

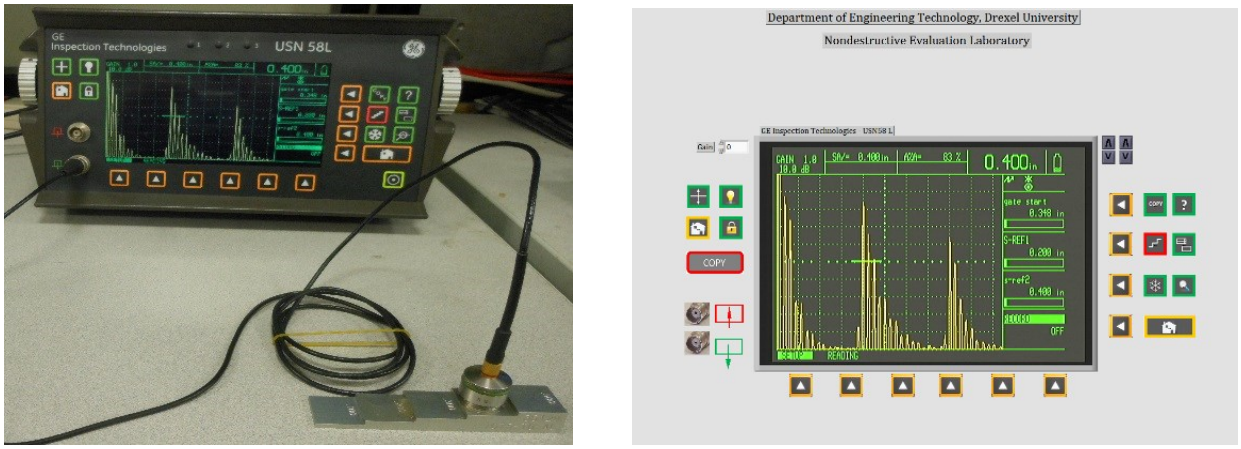

Figure 13. Front panel of USN 58L (left) and image of the front panel of USN 58L simulated on the computer monitor using LabVIEW™ (right).

The careful planning and the strategies we implemented at both institutions proved to be a great success in helping to not only retain students, but to assure that students received a quality education in a remote world. Asynchronous online, synchronous remote, mixed courses with Zoom and Canvas, and hybrid courses, allowed for different types of course deliveries to accommodate varying needs. The lessons learned and the innovative techniques we developed in the unwavering quest to continue teaching and engaging students during this unprecedented time,

will become staples to the future of education, and instrumental in its sustainability [22]. Strategies and resources will continue to be utilized and refined in the enhancement of course delivery and of College practices to cultivate a productive atmosphere, and to promote workforce readiness of our students. Continued dissemination of best practices will contribute to the sustainability of our educational institutions at all levels, and to the future of industry by producing a competent workforce.

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