Society for College and University Planning
SCUP Fellow Research Project Final Report

Smart Building, Smart Campus

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MEET ANGELA FOSS

Education has always been a passion of mine; I am a good example of a lifelong learner. My undergraduate degree is in computer engineering, and I was hoping to explore the intersection of computers, design, and art. While I had a strong interest in the field, it was difficult finding a role or environment that felt like a good fit for me. This is what ultimately led me to work in higher education.

At the beginning of my career I focused on helping students tackle math readiness, which is far too often a barrier for students in many disciplines, but particularly STEM. From there I explored the emerging modalities available to education and broadened the profiles of the students I worked with.

It was a privilege to help launch the College of Engineering, Technology, and Aeronautics (CETA) at Southern New Hampshire University (SNHU) as the associate dean of Operations and Innovations. The college had a focus on recruiting and retaining underrepresented students, because access and affordability are cornerstones of SNHU’s mission as an institution.

A large focus of my career has been on diversity, equity, and inclusion. The vision and mission of SNHU aligned well with my passions and interests and allowed me to bring many opportunities to life for students. I was able to continue
driving innovation at the university as the associate vice president of innovation, where we explored affordable degree options for campus-based and hybrid (partially online) students.

I knew I would eventually want to return to industry so that I could focus on similar challenges but from a new and different perspective. This is what led me to make the tough, yet exciting decision to join Autodesk in 2021. I now support innovation development as a network development manager within Autodesk’s research organization.

WHAT PROMPTED YOUR CHOICE OF RESEARCH TOPIC?

For my SCUP Fellows Program Research Project, I chose to explore the role of place, and experiment with remote and in-person experiences that could leverage the physical built environment as a learning tool for STEM disciplines.

My interest in this topic emerged as part of my work in launching CETA for SNHU. SNHU is a university that serves over 150,000 students online but also supports a small population on a somewhat traditional college campus in Manchester, New Hampshire. In my role at SNHU, I led the programming for a brand-new state-of-the-art engineering and technology building, The Innovation and Design Education Building. I supported the project from design to build, working alongside SNHU’s facilities, information technology, and capital project teams.

The Innovation and Design Education Building presented several unique challenges. SNHU never had an engineering college prior to the launch of CETA. We didn’t have a standard way of doing things. Additionally, I was tasked and empowered by SNHU’s leadership team to think of the future and to design and enable learning environments that may not be standard today. This had to be completed concurrently while weighing the immediate needs and requirements of the existing faculty, staff, and students at the college.

I had conducted a great deal of field research prior to my SCUP fellowship, visiting new construction sites at other engineering schools in New England, and attending national conferences like SCUP’s Annual Conference. I also visited one of SNHU’s partners in Ireland, IT-Sligo. IT-Sligo offers remote-based labs for students who are
pursuing credentials within STEM fields. This field research helped form my ideas and stimulated the exploration that became my SCUP Fellows research project.

I saw the exciting opportunity to explore the potential of bringing online learners virtually into the physical space. I imagined a truly “smart building” that could not only foster new ways of connecting, but could also become a learning tool for both in-person and remote students.

One of the biggest questions I had was could a smart building for STEM education reach more underrepresented groups, and what would the impacts be on pedagogy and traditional instruction models? Would a smart building begin to address the sustainability of physical campuses for colleges and universities? It was exciting to think about, and I was jazzed to dive in. I had the support of my leadership team, a few faculty members were on board, and I had a targeted group of students to work with. The study would explore the potential of accessing a building without being in the building. And right as we were getting started, that small experiment turned into an experiment for the whole planet. My research began at the onset of COVID-19, and all of a sudden this proposed concept seemed even more urgent and valid to explore.

Due to challenges with COVID-19, I was forced to adjust my research approach halfway through the work. I wasn't able to design a unique experience related to remote labs, but I luckily was able to gather some insights on remote learning in general. In the following sections I will share more about the work, my approach, and learnings.
THE PROJECT

HOW DID YOU APPROACH AND CARRY OUT YOUR RESEARCH PROJECT?

I began my research by diving into existing academic and business literature and re-examined some of my fieldwork. I learned there was already research and efforts to explore remote labs for STEM education, which were heavily rooted in electronics and some forms of robotics. So much so that there is even an Institute of Electrical and Electronics Engineers (IEEE) standard that provides a model framework for how to build and think through providing virtual access to a physical lab inside of a building. This knowledge connected with the site visit I conducted at IT-Sligo. The previous research proved that technology today is fully capable of supporting a “smart building.”

That led me to a bigger question: if technology can support remote work, then why haven’t the previous proofs of concept become fully adopted? What is preventing people from creating, accessing, and using remote labs more often? Based on conversations with faculty and students who had leveraged remote labs in the past, and through reviewing the literature, my hypothesis was that user-centered design would better address student needs, and could increase the likelihood of a broader adoption of remote labs.

Oftentimes the challenges for students in completing lab work had less to do with the curriculum and more to do with the instructions and setup of the remote lab itself. User-centered design and student-centered curriculum became a key component of my research for this project.

Another thing that I learned was the potential of augmented reality (AR), virtual reality (VR), or collectively extended reality (XR) in the physical-built environment. Museums are a great example of places that have been creating ways for visitors to interact, modify, and respond to the physical-built environment through XR (Squires 2019). The potential for students—both physically on a campus and remotely as online learners—really excited me as I thought through things like AR and virtual interactions.
I wanted to explore the role of place; can a building become more dynamic and support connections and instruction both on the campus and at a distance? I focused on two areas: remote labs and AR/VR interactions, and identified two student populations and two faculty members to support this research.

The first was a group of 15 students in a sophomore mechanical engineering course and their faculty member, who was the department chair of engineering. The faculty member and I worked with our partners at IT-Sligo to have the students participate in one of IT-Sligo’s remote labs. We would conduct a pre- and post-survey and collect feedback on the design and experience of the students. Following this work, the faculty member and I were going to build our own remote lab for his course.

The second student population was a computer science capstone team with their faculty member. The students accepted the project of designing a mobile application that would offer a virtual experience of the physical building at a distance. Essentially, they would build a mobile digital twin of the building with interaction points. This would include AR experiences for use when a user was physically inside of the building. The ultimate goal was to have campus computer science students build the app and then test the engagement of the app with online students.

As I began to set up my two focus areas and the experiments/projects that would go along with them, I reminded myself of my initial questions and goals for this research proposal. Will innovative environments like a smart building expand STEM education and reach more underrepresented groups? What is the role of place in learning, and how does it impact identity and belonging?

These were all exciting questions. I hoped that through my two projects I would have the chance to ask these questions of students engaging with real technology that extended the reach of a physical building.

Just as I was teeing up those two projects in March 2020, everything changed when the COVID-19 pandemic took hold. I had hoped to work with 15 students doing remote labs—and now the entire planet was thinking through things like remote access and remote instruction. The world was shutting down, priorities changed, and I was forced to pivot my SCUP Fellow research.
Research Pivot

My research experiment now had to shift to do work and studies at a distance—at my home, and with limited resources. The role of place dramatically shifted for the entire planet. How could experiences of connectedness be simulated at a distance? This was an amazing opportunity to learn and evolve in our thinking about place and learning—while in the middle of something as unfortunate as a global pandemic.

Sadly, the remote labs project had to stop. The faculty and students in engineering were overworked from the transition home and this would have become an added burden when they needed to reduce stress and focus on their priorities. But the capstone project for the computer science students was still a green light; we would have to rethink some of the development since we couldn’t be in the building.

In lieu of working with the engineering students and faculty in remote labs, I was presented with the opportunity to participate in a survey on remote learning for STEM students. I was connected with one of our engineering faculty members who was planning to survey all of the CETA students. Her survey goal was to get feedback from students on how they were experiencing remote learning. The faculty member hoped that the survey results would offer insights on how to improve remote learning if we had to continue remotely in the fall of 2020.

At SNHU there was a clear distinction between online learning (which SNHU has been conducting asynchronously for learners for many years) and remote learning, which in this case was often synchronous and meant to offer more points of engagement for students in the absence of face-to-face experiences. The faculty member agreed to let me incorporate a few questions into her survey for the purposes of my SCUP Fellow research.

FINDINGS AND IMPLICATIONS

As I worked through the pivot in my research, I continued to explore and work with the students on the mobile application with augmented reality features. But the second focus area went from remote labs and their user-centered development to remote learning in general for STEM students. By leveraging the survey that was going out to students during such troubling times, I learned unique items to apply to future work and development.
AUGMENTED REALITY MOBILE APP

The initial idea for the mobile application was to build a digital twin of the Innovation and Design Education Building. Interactive features within the application would allow users both at a distance and within the building to engage with the building. The requirements of those engagements needed to be determined as part of the design.

To begin this work, the computer science students treated me as a customer and conducted several requirements gathering sessions for the basic functionality of the mobile app. They had the software development competencies, but were missing some of the art development skills. I tapped into SNHU’s Inkwell Game Studio and identified a few students in SNHU’s game art program to join the team to support their development of the visual assets. Additionally, I worked with our general contractor and architect team to obtain copies of a 3-D model of the building for use by the students.

Some of our shop staff—who could still access the building—took multiple photographs of the location. The students successfully built a 3-D replica of the new Innovation and Design Education building, and the working proof of concept of the application was successfully built by the end of my research fellowship.

User-centered design was an area of importance to me. As the project progressed, I flipped the customer discussions to the students. What were the challenges or problems the students faced, and were any of them addressable through this application? The students were able to implement a few unique features based on their needs.

An example of a feature that solved a student problem was a room-scheduling feature. The students often wanted to use space when it wasn’t otherwise booked or occupied, but there was no central scheduling support to identify space availability and confirm use.

They developed a back-end database that could be updated by college staff that would display real-time bookings of space. This database could be built on current staff best practices for event booking and class scheduling. Students loved the idea of quickly understanding when a space was free for use; they could simply look at the mobile app.
While I had hoped to leverage the beta mobile app for phase two of my research—testing of engagement with online students—I was quite impressed with what the students had accomplished. Had time allowed, I would have wanted to better understand the value of a building/campus digital twin for use with students. Would students at a distance gain value through experiences with a digital twin? Would those experiences add to their learning? How could digital twins of a building support or engage students who were often in the building and on campus? What use cases would a digital twin offer for use with students?

Screenshot of the Final Product Designed and Developed by the SNHU Students
Two part project
1. Student led design of AR/3D mobile app
2. Testing of engagement with online students
Student Survey – Remote Learning

In the Spring of 2020, a survey was sent to 320 CETA students asking them a variety of questions about their remote-learning experience since March of 2020, and 84 students responded.

GEN.1 - My major is

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Student demographics of the survey given to CETA students in the spring of 2020
I added the following questions to the CETA survey for my SCUP Fellow research:

1. Are there websites or online services that you found on your own to help you learn (e.g., specific YouTube videos, Khan Academy)?

2. What are your current barriers to success learning remotely?

3. I learn best by...
   a. Watching videos
   b. Playing games
   c. Doing
   d. Reading
   e. Listening to instructions
   f. Working with peers

4. Describe how you stay connected with others.

5. Compared to before spring break (on-campus learning), my “hands-on” learning experiences are?

6. Please provide feedback on the quality of your “hands-on” learning experiences.

**These were the responses:**

- YouTube was the #1 reported outside resource leverage for class.
- Space at home can be a barrier, due to technology and distractions.
- Students reported that they learn best by doing.
- During remote learning, students stay connected with peers through social media and other digital forms.
- Students indicated their work increased through reading and writing, but they had fewer hands-on experiences.

In many ways these results were what we had expected. Students missed some of their previous “hands-on” experiences. They reported that they learn best by doing, and that was a pivotal part of their educational experience. And while remote learning can offer those hands-on opportunities, the sudden move to remote learning did not allow enough time for the development of more robust hand-on experiences. One student commented on the question of barriers to learning and technology: “It is more that I have had glitches with programs that I need to use,
and I spend more time figuring that out than being able to do the homework that was due.” This is a great reminder that user-centered design of remote hands-on experiences is important.

Another student commented: “When the programs (technology) we need don’t work, doing assignments takes forever, and therefore we lose interest and get frustrated.”

Well-designed and supported activities could be valuable, but the access and technology troubleshooting features are really important for the success of a remote-learning experience. If students have trouble simply accessing the materials, it can be a significant problem.

Understanding the student when designing for the student can go a long way. Ultimately, the survey provided a foundation of support for user-centered design when designing remote labs. The survey results also highlighted the unforeseen challenges that can be deal breakers for students when leveraging technology in an environment (i.e., remotely at a student’s home) that the designer cannot control.

As remote learning and hands-on activities continue to be an option for higher education, my hope is that students will remain engaged in the development of these experiences, and that appropriate technology support systems will be in place.

**WHAT LESSONS FROM YOUR RESEARCH WILL HELP OTHER PLANNERS AND BENEFIT THEM IN THEIR WORK?**

While my research had to pivot due to the COVID-19 pandemic, I completed it with an adjusted lens. Several themes emerged from my research, and these are the lessons I gleaned:

1. **Plan for hybrid campuses and remote experiences.**

   The pandemic simply accelerated our move to more hybrid experiences. Those would be experiences that support individuals both in-person as well as remote or online at the same time.
With growing interest and need for flexibility, hybrid options will be a requirement for most academic institutions. Individual curriculum and student experiences may not always need to support hybrid interactions, but campuses should be equipped to support remote experiences. Remote experiences have shown their value during the pandemic and offered alternative access and engagement when being in-person has not been an option. I saw the power of this in my work for this research fellowship.

Feedback from students also emphasized the need to support hybrid learning and remote offerings as well as the quality of the engagement. Support beyond typical technical troubleshooting will need to be in place to ensure students can focus on what is most important—the designed experience. Appropriate infrastructure support will also be key to enabling the engagement that students, faculty, and staff wish to have.

Lastly, staff and faculty training and development is an area that needs to expand beyond historical pedagogy and best practices. New ways of thinking about teaching and learning will offer greater opportunities for improved learning outcomes and student engagement.

2. **Include students in the design of your campuses, curriculum, and experiences.**

As I reflect back on my career in higher education, it is egregious to think about the number of programs, curriculum, and services that I’ve witnessed and participated in developing that did not engage students at all. Students should be at the center of the work. The collective “we” in higher education many times states that students are at the center, but in practice it often does not play out that way.

In my experience we often make assumptions about students’ needs or wants that continue to reinforce the traditions of higher education—when the focus should be on student learning and success.

We can learn from user-centered design. Go beyond reviewing survey results or tapping a few student representatives for input on a given project. Test out radical involvement of students. An example would be to leverage project-based learning and have the students design the program or do the “work” as part of
the curriculum. (And I suggest this while knowing that others have completed one-off projects like the one I did with the computer science and game art students. However, what I’m referring to is more widespread and involved.)

My work with the computer science and game art students at SNHU opened my eyes to so much potential. SNHU could have hired a company to develop a mobile application for use by campus with a set of requirements. But who better than the students to design an app that ultimately they would consume. I’m grateful to those students and their faculty members for the opportunity to work and learn from them.

3. **Experiment with, and integrate new technologies.**

You may have heard about emerging technologies like Web 3.0, digital twins, or the metaverse, which may sound like trendy buzzwords. Emerging technology impacts educational environments and offers unique learning and development opportunities for students. The more that college and university campuses enable students to experiment with these technologies, the better prepared they will be for the future.

I encourage higher education organizations to think through experimentation space on their campuses and externally with industry partners. Today, I sit at one of Autodesk’s Technology Centers, an open innovation space where external teams focused on future-thinking research projects can experiment, collaborate with a global network of innovators, work in data-enabled fabrication workshops, and tap into a robust set of programming designed to support their work. This is the type of engagement college campuses should be seeking with industry as technology continues to rapidly evolve.

My work with SNHU CETA computer science students was not only exciting but also productive. The digital twin the students developed for the IDE building offered real-time updates on space utilization, creating many opportunities for engagement and learning. Buildings don’t need to be static. Smart buildings are becoming more prevalent and digital twin environments are proving to be helpful as they continue to educate us on how to offer more functionality. New cloud-based platform titles like Autodesk Tandem continue to build use cases.
for leveraging digital twins by providing insightful data to building owners and operators.

The metaverse will take digital twin use cases to areas we have yet to even imagine. It is important that the SCUP community participate in the research, exploration, and influence the adoption of how these emerging technologies show up in higher education and campus planning. As an example, 3-D immersive environments like the metaverse are already being adopted by students and industries—but how will that impact, influence, distract, or support our efforts with learning? Will inequities continue, or are their ways to support even more inclusive educational opportunities? Digital twins within the metaverse may need to be managed or planned for as part of campus planning. While these technologies can feel overwhelming, I for one am excited for what might be possible and hope to help shape the future in a way that supports us all.
LAST WORDS

HOW DID YOUR SCUP COACHES SUPPORT YOU IN YOUR PROJECT?

I was very fortunate to have four amazing coaches as part of my SCUP Fellowship. Amber Luther was an invaluable coach and support during my project. She often pushed me to think bigger, or led me to work I hadn’t previously considered. Her work with Populous and the campus of 2030 was a great reference and network to tap.

Lev Gonick shared great advice and guidance from a campus technology perspective. He offered a reality perspective on the challenges larger campuses face with technology adoption. He was even up for a bit of playful razzing: I am a University of Arizona alumna.

Mary Beth McGrew, as a campus planner, was in real-time giving me insights into the challenges that students and faculty faced during the height of the pandemic. Her perspective as a coach helped round out my understanding of campus planning and informed my research.

Brian Ryckman, the former STEM librarian at Southern New Hampshire University, helped me navigate my research within the SNHU ecosystem. Because SNHU is not a research institution, Brian’s guidance of appropriate approaches and methods to this work was irreplaceable.

As the world shut down at the beginning of the pandemic, I found our calls together as a team not only helpful for me and my research, but they also offered a community feeling of support during tough times. We were able to discuss real challenges facing our students, families, and friends because of the pandemic. I’m thankful for their time, support, and encouragement.
Lev is an educator, technologist, and smart city architect. He has been teaching, working, and living on the internet for more than 25 years. As chief information officer at Arizona State University, he leads the ASU University Technology Office that provides technology services to all students, faculty, and staff. He is also cofounder of DigitalC, previously OneCommunity, the award-winning non-profit organization enabling and celebrating innovation, collaboration, and productivity through next-generation broadband networks, big open data solutions, and IoT for public benefit.

Amber is a designer and principal at San Francisco-based Populous. For 20 years she has focused on planning and design of large assembly facilities, collegiate facilities, and master planning and urban design.
For the past 15 years, Mary Beth has worked inside urban institutions of higher education specifically at the University of Cincinnati and more recently the University of Pittsburgh in the areas of planning, design, construction, real estate, sustainability, and community development. These experiences followed years of work in large multidisciplinary firms. Throughout her career, engagement with SCUP, sometimes as a presenter and for many years in the Academy, has been part of the equation. She adds that “this current project with a SCUP Fellow was completed during a difficult time with the pandemic, but it did not stop vibrant conversations with a creative idea put forth by the Fellow and the conversations with the coaches. The time was well spent.”

Prior to working for IEEE, Brian worked as an academic librarian for 18 years at universities in Michigan, Florida, and New Hampshire, with interests in information literacy, scholarly communication, and collection development. Most recently, he was the STEM librarian at the Harry A.B. and Gertrude C. Shapiro Library at Southern New Hampshire University.

SCUP fellow coaches are volunteers who are experienced in an area of higher education or thought leadership that is aligned with the ultimate goals of the SCUP Fellow Research Project. They bring fresh perspectives and insights over the course of the fellowship year. We thank Angela Foss’s four SCUP coaches for their generosity of time and perspective.
CONCLUSION

In the fall of 2017, I met senior planner Maria Musat (and SCUP member) from the University of Ottawa. I shared with her that I loved exploring campus planning and its intersection with technology. I was excited and interested in the innovations that could create a more equitable and supportive learning environment for students, and was curious about how I could continue this work even after the Innovation Design and Education Building project I was working on was completed. I will forever be grateful to Maria who suggested that I investigate the SCUP Fellows Program. It was a fruitful and invaluable experience for me, and I learned I have a love for the influence of space on our well-being and, ultimately, our ability to learn and grow. Through my fellowship I was able to expand and diversify my network in ways I hadn’t previously had the opportunity to do. I also appreciate the opportunity to capture and quantify the professional development and experiences I gained through working on an innovative design build project. The exposure to more applied forms of research and research within a professional network such as SCUP is a great way to add exposure to your topic both internally at your institution and externally.

I am grateful to my colleagues and the students at SNHU for their encouragement and support with this research. I would also like to thank HGA Architects and Skanska for their support and for teaching me so much throughout the CETA building project.

I ultimately decided to change careers and move back into industry. My SCUP fellowship and the excitement I had working with the students on innovation development sparked my curiosity to explore other environments where I could continue to pursue similar work. During my research I worked with and alongside Autodesk software. I enjoyed learning about the intersection of various industries and the technologies they leverage. And as a result, I investigated opportunities to continue to support this type of research in industry. My SCUP fellowship sparked my interest and increased my ability to continue my career with similar focus areas but from new and differing perspectives. Now I conduct innovation development within Autodesk’s research organization. Thank you, SCUP, for the interest in my work, support, and the spark I needed to take my passions and work to the next level.
REFERENCES


