Owned by All, Shared by All: Makerspaces at the Center of Today's College Experience

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J.R. Campbell¹, Allen Kachel², Joshua Keller³, Rachel Switzky⁴

¹Director, Design Innovation Hub, Kent State University; email: jrcamp@kent.edu

²Architect, Senior Associate, Bohlin Cywinski Jackson; email: akachel@bcj.com

³Architect, Associate, Bohlin Cywinski Jackson; email: jkeller@bcj.com

⁴Director, Siebel Center for Design, University of Illinois at Urbana-Champaign; email: rswitzky@illinois.edu

Introduction

The complex challenges of our time require interdisciplinary thinking and collaborative problem-solving. As boundaries between disciplines blur and academic inquiry blends with entrepreneurial drive, higher education institutions are increasingly seeking to position collaborative, experiencebased problem-solving and maker environments as essential components to education. This growth has led to an emergence of the freestanding interdisciplinary makerspace as a campus-wide resource, offering access to tools for research, prototyping, and collaboration and putting making at the heart of the higher education experience, from both a pedagogical and physical campus planning perspective.

These makerspaces gather technical and non-technical tools in a central location, rather than former models of dispersed, 'specialized' tools in locations owned by or aligned with specific programs, such as engineering shops or fine art studios, thus scaling the transformative experience found in departmentally-focused makerspaces to engage the entire campus. Accessibility, equity and inclusion, ease-of-use, and round-the-clock access allow students from all disciplinary programs to learn by doing to better prepare for diverse academic and professional pathways.

This paper shares strategies that can be used in the design of makerspaces to reinforce an "Owned by All, Shared by All" philosophy. From post-its to robotics testing, these spaces remove barriers to entry for English and engineering majors alike and offer a range of tools to support the full cycle of problem-solving, prototyping, and testing for any project.

Using two very different non-departmental projects as examples – Kent State University's Design Innovation Hub and the University of Illinois at Urbana-Champaign's Siebel Center for Design – we present thoughtful ways in which the architecture of a facility reinforces a program's mission. We will share strategies for early project planning, space utilization, and designing for flexibility, and how they support increasingly prevalent modes of learning and doing: teamwork, breaking out of specific silo or focus, and teaching empathy, awareness, communication, and collective visualization. We will also explore how balancing 'unprogrammed' space can help lower the barrier to entry for students and remove (at least some) of the fear of failure in experimenting with possible solutions.

Context

Collaborative maker environments build on longstanding creative educational models such as the Bauhaus School and Taliesin West—open studio cultures that value a crossdisciplinary approach to education and community-building [1]. Within these creative spaces, the integration of high-tech tools and scientific process further break down the divide between technical problem-solving and creative exploration.

As well as providing dynamic spaces for students of varied academic departments to integrate design thinking and making with their own studies, interdisciplinary maker environments can help students understand how a specific area of focus intersects with broader contexts. As Leah F. Rosenbaum and Bjorn Hartmann noted in their 2018 ISAM whitepaper and study, Making Connections, Project Courses Improve Design Self-Efficacy and Interdisciplinary Awareness, "participants reported a statistically significant increase in perceived value of learning with students from other academic disciplines" within maker environments [2]. This broader understanding gained from collaborative crossdisciplinary work is one of the reasons more institutions of higher education are investing in free standing buildings that house significant campus maker environments. Well known examples range from the d.school at Stanford University and Jacobs Hall at UC Berkeley to recently completed environments like the Penn State Design Innovation Hub and Student Innovation Center at Iowa State.

This paper builds on aspects of Ownership and Governance models described in Bohlin Cywinski Jackson's previous paper, *The Impact of Mission, Ownership, and Governance on Shaping the Academic Makerspace*, presented at ISAM 2019, and is co-authored by the firm's clients and collaborators at Kent State University and the University of Illinois Urbana-Champaign. The Siebel Center for Design is a "Multi-Disciplinary Center," with spaces that support inter-program collaboration, independent programs for inter-program collaboration, and fully independent programs. A broad mix of equipment that includes less specialized fabrication tools appeals to a large student user base and lowers the threshold of engagement otherwise faced with more specific or highly technical features. This model also typically demands more collaboration spaces and amenities to build a sense of community.

The Design Innovation Hub is a "Student Resource Center," a model that approaches the makerspace ecosystem across Kent State's eight-campus system as a university-wide student resource. These facilities can fall under the governance and ownership of non-degree departments, such as student services or honors colleges, but are most commonly incorporated into libraries and learning resource centers. Because they are operated under a different funding model, they are distinct from the multi-disciplinary model.

Identifying a Location

A central, highly visible location that is connected to the dayto-day life of an institution can be instrumental in putting learning and interdisciplinary thinking on display and providing a dynamic hub that students, faculty, and staff from varied disciplines and departments can feel ownership in. Available space, master plan requirements, opportunities to preserve or elevate campus history, and other considerations present unique parameters that vary by institution and impact decision-making when determining whether a new build or adapting or repurposing an existing building is most appropriate. In determining site selection, is also important to consider how both internal (programmatic, organizational) and external (integration with campus context) adjacencies will reinforce overall mission and goals.

Defining planning and decision-making processes, as well as identifying stakeholders, and existing resources, are critical early steps in the process of creating a standalone, "Owned by All, Shared by All" environment. Identifying and mapping existing assets and tools can be a powerful exercise in understanding what students can access and deciding what should be included in a central, interdisciplinary makerspace.

The emergence of higher education makerspaces within existing campus buildings, from libraries to student unions, is well documented. The increasing importance of these environments to an interdisciplinary higher education experience means that a dedicated, standalone building can help position an institution well to adapt to evolving practices. Creating a standalone environment, particularly one with a mission to welcome and support the campus at large, presents opportunities for new programmatic and organizational methods. A new build, or adapting an existing building for new use, involves different considerations, including economics, space constraints, or the opportunity to preserve campus history and context.

Adaptive Re-Use / Revitalizing Existing Buildings

The 78,000 square-foot Design Innovation Hub at Kent State University is an adaptive re-use of the John Andrewsdesigned former School of Art building at the center of the Kent, Ohio campus. Located next to the historic site of the May 4, 1970 shootings and the Esplanade, a main campus thoroughfare, the building opened in 1972 and was celebrated for its ambitious design, with strong cellular geometry and an expressive spirit.

Both in its philosophy of architecturally promoting crossdisciplinary collaboration (in this case between distinctly separate studio art programs) and in its use of new materials, the building functioned as an architectural 'intervention' on campus while conveying the need for innovation in academic engagement. The original design encouraged student dialogue and collaboration through cut-outs and views between studios, and featured material use that was innovative in its time, including a translucent insulated wall panel exterior that created diffuse light throughout the interior.

When the School of Art relocated to a new space in 2016, however, the building's future was in doubt; many of its once innovative elements and materials were at the end of their useful life. The University had also embarked upon a new master plan in 2018, revealing a need to create more maker resources to help prepare students for an increasingly interdisciplinary world. Learning from MIT's Mantus network of makerspaces, university stakeholders in the Design Innovation Initiative mapped all existing maker resources and facilities on campus. They then developed a hub that would link maker offerings across campus. The Design Innovation Hub is many students' first introduction to the "Maker Ecosystem" on campus.



Fig. 1 The DI Reactor within the Kent State University Design Innovation Hub © Ed Massery Photography

While the School of Art building had been considered for demolition given the extensive work needed, close collaboration between the design team, construction manager, Design Innovation initiative faculty, and the University Architect was essential in evaluating and understanding its adaptive re-use potential. Balancing the feasibility of re-use vs. demolition, its notable design legacy of creativity and innovation, expressive structure, and central campus location, the team ultimately decided that an extensive re-envisioning would provide an ideal home for new generations of creative minds for another 50+ years.

Adaptive re-use allowed the design team to create an inviting maker environment that continues to convey a collaborative innovation mindset. Analyzing the cross section of the original building, the team identified the northern end of the first and second levels as ideal for the DI Hub maker environments, as seen in Fig. 1, where the building's industrial character, tighter floor-to-floor height and dynamic connections would align well with visual supervision and acoustical separation. This approach also allowed for the entire third floor to be redesigned to host the second largest dining facility on the Kent Campus. Re-use of the original building's steel structure resulted in significant embodied carbon diversion while creating an ideal framework for a range of creative activities.

Ground-Up Makerspace

The Siebel Center for Design at the University of Illinois, Urbana-Champaign is one of the only ground-up interdisciplinary design centers of its kind in the United States. The building supports the mission of the Siebel Center for Design, created to champion human-centered design and encourage a collaborative approach to problem-solving—one that combines design thinking, experimentation, prototyping, and making.

The Siebel Center for Design anchors the Military Axis, a large green space, and is adjacent to a main road through campus and several pedestrian paths, as seen in Fig. 2. Early in the design process, the project team evaluated multiple sites to determine an optimal location, considering accessibility, synergies with related programs, impact on the University master plan, and the ability to support desired program size.

We considered sites closer to the University's campus center, including several near the existing School of Engineering. The building site, as a terminus to the western end of the Military Axis, was ultimately selected because the building would not be perceived as being tied to a specific discipline and was surrounded by student housing as well as schools of art and design, business, education, and more. It also did not require additional vehicular parking and offered natural integration with established campus pedestrian and cycling routes.



Fig. 2 Diagram showing Siebel Center for Design location and adjacencies to surrounding academic and student life buildings.

While the campus master plan called for a four-story building as a formidable terminus to the Military Axis, we concluded that a two-story structure would locate program areas near one another to maximize collaboration and visual connection. From the onset of the project, there was a strong desire for a transparent building that would showcase the innovation within. Positioning the Siebel Center for Design's lower level underground maintained sensitivity of scale in its setting and allowed for a highly transparent pavilion that achieved significant performance energy goals. Along with its high degree of transparency, the design invites students into and through the building using centrally located interior and exterior gathering spaces.

Makerspace for All

Beyond location selection, the design process for both projects developed strategies for attracting visitors, encouraging exploration, instilling a sense of ownership in the makerspace, and supporting the growing culture of making at each school. These strategies help promote a broader understanding of the diverse tools, spaces, and activities within, in turn fostering greater adoption and creative exploration by students across academic departments.

Welcoming Social Space

As environments that gather and foster institution-wide creativity and collaboration, "Owned by All, Shared by All" makerspaces can play an important role in meeting campus needs beyond specific tools or shops, while offering gradual immersion into creative exploration. At the Siebel Center for Design and the Design Innovation Hub, project teams found that adding informal gathering space can, in turn, provide richness to the overall makerspace experience. This programmatic mix has been successfully employed in other makerspace environments as well – in one example, speaking to *Forbes Magazine* in 2020, Liz Orwin, former engineering department Chair at Harvey Mudd College, noted that "We were intentional about the layout of the space and how to draw people in...", creating both a comfortable lounge and coworking space as early experiences [3].

At the Siebel Center for Design, an outdoor terrace with colorful furniture, entry lounge and café with flexible seating, and expansive Gallery with casual, movable furniture provide a range of options for students to meet over coffee, work amongst others, and explore the building. The design team intentionally integrated informal 'nooks' of varied scales throughout each level, providing students with myriad opportunities to find the right fit for individual or team-based work, whether or not they were attending a class or working on a specific project. Considering the appropriate amount, location, and character of social space with the overall project team early in the design process will help ensure the building program is right-sized and square footage remains as efficient as possible.

Through post-occupancy interviews with Siebel Center for Design staff, the design team has explored how these spaces have been used, and the importance of providing needed flexible space, particularly during the upheaval of the COVID-19 pandemic. Students have cited the "extreme access" to open collaborative areas in addition to classrooms and studios. These spaces are used for a variety of functions, from quiet studying, to rehearsing a presentation, to gatherings of student organizations.

The prioritization of flexible, easily reconfigurable furniture and collaboration tools has been shown to be highly successful, as students have taken ownership of these spaces to suit their needs, embodying the DIWO character of making. At both the DI Hub and Siebel Center for Design, small study rooms, booths, and casual seating and tables provide myriad opportunities for students to find their place within the overall environment. Siebel Center for Design staff recognize that the diversity of spaces and adjacencies create opportunities that "just aren't widely available for students around campus" and have provided immediate benefit for students since the project opened. This feedback has been echoed by faculty from different colleges on the UIUC campus, who note the agility and flexibility to make the space "theirs" and easily configure based on their needs. Without ties to a specific discipline, the campus community knows that this is a space where anyone can convene, collaborate, and test new ideas.

Visual Connection & Resource Organization

outdoors to indoors, and between different From visual connection is environments. an important consideration in welcoming a broad range of users. So too is the organization and adjacencies of available resources within a makerspace: everything from systems integration to which workshops sit next to each other factor into design decisions. As the University of Minnesota Twin Cities' Rami Jubara and Tiffany Reichard noted in their 2019 ISAM abstract citing findings on campus makerspaces, "A further barrier to access was that the existing campus makerspaces typically housed 'higher level' maker equipment with the assumption that users were already familiar with the technology.



Fig. 3 The Siebel Center for Design's central Gallery © Jeffery Totaro Photography

This can create an intimidating atmosphere for users who are just starting to explore maker technologies" [4]. In student town halls early in the design process, the Siebel Center for Design team received confirming feedback that complex technical projects can be exciting to some students while leaving others intimidated, so we carefully considered how different shops and tools were choreographed within a space, and related to one another, to encourage immersion and spark creativity, as seen in Fig. 4. Offering visible connections between brainstorming areas, coding and software stations, woodshop and analogue tools, and high-tech fabrication machines helps promote holistic thinking at every step and encourages students to explore solutions that might not have emerged otherwise. This visibility also builds confidence for students who want to learn how to use new tools and expand skillsets, building a peer-to-peer culture of teaching and learning.

Within the DI Hub, the design team used the original steel structure to create an intuitive flow between circulation paths, specialty shops, and collaborative areas. The team created the "DI Reactor" – an expansive brainstorming space for groups of various sizes, with re-configurable tables and hand tools to support entry-level making. Shops facing onto the DI Reactor provide visual connection to a range of specialized tools. This balance was vital to an accessible makerspace that offers paths for students to build skills and confidence at their own pace.

While celebrating the original building's steel framework as an organizing principle, the design process also acknowledged that "design innovation" as a concept at the University will continue to evolve over time. Paring much of the interior to an intentionally limited material palette and utilizing movable worktables and furniture throughout prepares spaces to adjust to changing pedagogy and accommodate new equipment.



Fig. 4 Diagram showing spaces for inspiration, ideation, and implementation on the upper floor of the Siebel Center for Design.

Openness, flexibility, and daylight and view access throughout the DI Hub create an environment that is fundamentally healthy and responsive. At the Siebel Center for Design, the project team integrated flexible, low energy mechanical systems into the architecture to preserve the highly changeable, functional, transparent nature of the building. These systems, along with the building envelope, provide a high-performance solution that minimizes energy consumption with economic design.

Tools & Technology

As well as a variety of environments, a sense of choice is important when considering not only which tools to include in makerspaces, but how selection, diversity, and visibility provide a sense of opportunity and provoke curiosity in users with wide-ranging skillsets. Tools and technologies that serve broad swaths of the campus population with minimal training or instruction can lower the barrier to entry and provide gradual immersion, experimentation, and a sense of inclusion. Careful thought in how tools are displayed and accessed can be beneficial in creating a welcoming environment for all.

At the Siebel Center for Design, we located the multimedia lab and reservable studios and classrooms equipped with a/v technology along the central Gallery, providing direct access to tools that can be more self-directed or involve small-scale, low-fidelity instruction and exploration. These rooms provide quiet areas for focused editing or rehearsing and refining pitches and presentations. We located the Shop, the building's core makerspace, on the lower level, providing both a highly visible from the central pathway and one separated from open collaborative spaces for noise considerations. Visitors entering the Shop first encounter a welcome area and checkin desk, with a staff member ready to provide information. The Shop is split into an area with rows of movable worktables for flexible team and digital fabrication, and a separate but accessible room for specialized fabrication, with larger equipment like a CNC router, waterjet cutter, table and miter saws, a drill press, and other related equipment. In addition to noise and dust considerations, this separation provides clear delineation between more technical equipment requiring specialized training and safety considerations, while providing an immersive area populated with FDM and SLA 3D printers, sewing machines and other equipment to encourage collaboration within a messy "shop" environment. Visual connections between the two maintain continuity, and card access at each piece of specialized equipment allows students to safely view all of the Shop's offerings without fear of unauthorized use until students are trained by shop staff.

Analog tools can also encourage students to get engaged and feel a sense of ownership in "making the space theirs." The project team integrated fixed and flexible writable surfaces throughout the Siebel Center for Design to encourage wide use. This includes double-sided whiteboards on castors, gallery walls, and writeable wall surfaces in classrooms. Postoccupancy interviews with staff have highlighted widespread use in many ways, from students writing their preferred lighting settings at classroom entries to small groups moving whiteboards up and down the central pathway for use as both a creative tool and space-defining element in nooks throughout the building.

Accessibility

The University of Illinois is committed to providing universally accessible services and opportunities to everyone on campus. At the Siebel Center for Design, we created a prominent reminder of this pledge, especially fitting for an interdisciplinary makerspace. While initial project discussions contemplated a social stair as a central node for gathering and moving between floors, we quickly realized the accessibility limitations it would present, and pivoted to provide a prominent, accessible pathway that ultimately became a more resonant central feature to a project with a mission to welcome the entire university community. The gently sloping pathway at the light-filled heart of the building serves as a central crossroads for students moving between shops and studios, creating a vibrant thoroughfare traveled by all [Fig. 5]. The main circulation route linking the building's two floors, the pathway is also an active design element that



Fig. 5 The central pathway and amphitheater at the Siebel Center for Design @ Jeffery Totaro Photography



Fig. 6 The DI Hub dining hall © Ed Massery Photography

promotes wellbeing. The curve of the path as it reaches the lower-level wraps around the building's 'amphitheater,' which hosts lectures, readings, performances, discussion groups, and more. The pathway also supports programmatic visibility and connection: as visitors move between the open Gallery, flanked with classrooms, down to the Shop, tool library and other collaborative areas, the building's diverse ecosystem is fully apparent.

Food for Thought

Unique to the collegiate makerspace typology, the DI Hub houses a significant dining component, an active campus hub for student life [Fig. 6]. Uniting distinct programmatic requirements meant balancing the needs of a significant foodservice environment and studios and labs that house sensitive equipment facilitating everything from water jet cutting to robotics testing. Bringing food service and making under one roof achieved several goals. In coordination with Kent State's holistic review of campus dining, the dining hall met the need for new, better distributed and more accessible facilities, particularly along the heavily used Esplanade. The dining hall also provides a natural path to exploring the DI Hub. Combining a makerspace with a dining facility that can serve a third of the campus population daily was a strategic move to put making on display as a core feature of the University's academic framework: this is where students break bread and problem-solve together. There were other efficiencies gained by bringing these programs together. Working with the two user groups, we successfully reduced the requested square footage in gathering, seating, and gallery spaces by 16%. This was achieved by locating multi-functional space at key locations, accessible to both user groups that each have different demand times. This reduced cost and provided a more vibrant and lively campus building in the process.

Integrating broader, structured community use within more technical or specialized spaces can be a powerful way to drive greater engagement. As Jubara and Reichard further note in their 2019 ISAM abstract, "As the Makerspaces gained traction, student volunteers, library staff, and other interested campus community members stepped forward to share their skills through workshops focused on one of their hobbies or interests. This widened the scope of what "making" can mean in the Libraries Makerspaces" [4]. The Design Innovation Fellows Suite is an open co-working and hangout space for Design Innovation Fellows students and students participating in the DI Fellows Program. The suite is an openplan environment that is shared with DI administrative staff, as DI Fellows serve as shared leadership for the Design Innovation Initiative. The space includes a main studio, a shared seminar space, small conference rooms and telephonebooth-style rooms for private conversations. The Siebel Center for Design's Garage, a high-bay space with a roll-up garage door and adjacent maker courtyard, has housed various uses including a collaboration with UIUC's Japan House to host a boat builder for a weeklong workshop. Having the builder and students working successfully together within the Garage brought new users into the space, broadened conceptions of "making," and encouraged planning for more curated collaborative activity in the future.

Conclusion

Successfully fulfilling the mission of a maker program requires a thoughtful synthesis of curriculum, community, and facilities. This paper has illustrated how standalone interdisciplinary makerspaces can provide not only the tools but strengthen curriculum and help build a collaborative culture and community as a central campus resource that all can feel ownership in. In the process of elevating makerspaces from basements, garages, and lesser-used spaces on campus to freestanding, highly visible, easily accessible buildings, collaborative effort between architects and academic stakeholders is essential in key decision-making, from site selection to space planning. This is the process that creates environments that foster collaborative spirit and community and bring experience-based learning to an entire campus.

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