Conceiving and Preparing for Innovative Learning Spaces

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Abstract

Purpose

The University of Windsor’s Ed Lumley Centre for Engineering Innovation (CEI) represented a unique opportunity for collaboration between architects, faculty, and educational specialists to create a next generation learning space that enhanced learning. This paper discusses the design processes, faculty development, and student impact.

Approach

Designing space to facilitate a specific pedagogical approach, such as CDIO, requires interdisciplinary teams to develop a shared language. This was facilitated through dialogue and team members able to translate technical language from multiple disciplines into design concepts. Post-occupancy surveys assessed the student impact.

Findings

Flexible spaces that promote collaborative learning were a key focus of the design. The building includes informal areas such as lounges, a café, student-scheduled meeting rooms, and a green roof terrace. The “Live Building” design uses sensors can integrate data from almost every aspect of the building operation into active teaching, learning, and faculty research. Another important achievement is a 350-person classroom that is 60% accessible, including novel reconfigurable furniture supporting collaborative learning, break-out displays and a flexible technology backbone for future expansion.

Implications

Gaining buy-in for active, collaborative teaching is critically important. A series of professional development events was organized for faculty to facilitate pedagogical renewal and innovation. The value of the design process is discussed with post-occupancy data based on student survey results. Similar projects are becoming more common in higher education. The process undertaken here provides a useful framework for these projects.

Value

The interdisciplinary approach to purpose-built learning environments provides a model for pedagogical change.

Keywords: next generation learning spaces, intentional design, pedagogy, collaborative learning, interdisciplinary team, CDIO
Introduction

An important driver of student engagement and achievement, as well as productivity in research, is the suitability of the physical space for its purpose. The Joint Information Systems Committee (JISC) argue that “Spaces are themselves agents for change. Changed spaces will change practice.” (JISC, 2006 P.30). In 2006, it was recognized that the Faculty of Engineering at the University of Windsor (Windsor, Ontario, Canada) had outgrown its 50 year-old physical space, both logistically and pedagogically, and would need a new space to take it into the 21st century, including making significant pedagogical changes to meet the needs of the student body and society at large. The $112 million Ed Lumley Centre for Engineering Innovation (hereafter referred to as the CEI) represented a unique opportunity for collaboration between architects, faculty, and the Centre for Teaching and Learning (CTL). A multi-disciplinary committee, composed of architects, engineering faculty, and teaching and learning specialists, focused on collaboratively identifying the needs of current and future students and faculty, and designing a flexible, living building to meet these needs, and supporting the transition to using the new space.

With the “blank canvas” of designing a new building to meet the specific needs of engineering students and faculty, it was necessary to consider how pedagogy, space and technology interact to enhance learning and teaching, especially through immediate feedback and flexible re-configuration. Furthermore, since the design process was initiated six years prior to the opening of the building, it was necessary to predict the necessary technology that would be current when the building is used for the first day of classes.

This paper will examine the collaborative design process, faculty development activities, and preliminary results from early post-occupancy studies.

CDIO as a Pedagogical Basis for Learning Space Design

The CDIO Initiative which stands for Conceive-Design-Implement-Operate is a pedagogical approach utilized in engineering that was developed by four institutions in the United States (Massachusetts Institute of Technology) and Sweden (Chalmers Institute of Technology Gothenburg, Linkoping Institute of Technology, and Royal Institute of Technology) (El Gaidi, 2003), largely as a response to a growing perception in the industry that graduates were technically competent, but lacked many of the other skills that practicing engineers needed such as team work, communication skills, and media/marketing.

CDIO is a pedagogical framework that has been embraced by over 90 institutions around the world in the last decade (cdio.org, 2012; Berggren et al. 2003). The CDIO pedagogy aims to develop graduates with a deep working knowledge of technical fundamentals; leadership characteristics that allow them to create and operate new products, processes and systems; the ability to recognize the strategic value of their work, including socio-cultural aspects (cdio.org, 2012; Crawley et al, 2007; El Gaidi, 2003). Success in achieving these goals requires close interaction and
communication between instructors and students and students with their peers in a collaborative learning environment (Liang et al. 2011). The curriculum must be rich in student projects and industry internships, active, experiential and group-based learning opportunities, and access to modern, industry-standard learning spaces that are highly networked and accessible to the outside world (El Gaidi, 2003; Strong & Stiver, 2005).

This last point was critical to the present project as the learning spaces used by the engineering program were mostly very old traditional spaces with fixed seating, little access to electricity or networking and not conducive to collaborative work. Oblinger (2006) argues that the concept of built pedagogy (the ability of a space to influence how one teaches) is becoming more and more powerful in the higher education sector as universities and colleges struggle to make the kinds of pedagogical changes that are required to equip current students with the skills and knowledge they need to succeed. Strong and Stiver (2005) point out that there is a clear need to couple pedagogical approaches with purpose-built learning environments, especially for project-based collaborative learning and to model professional works spaces. Goldberg (1996) also argues that such spaces should also provide a hub that could develop professional relationships and act as incubators of entrepreneurial activities. Until recently however, such learning spaces were rarely found in North American engineering schools, thus providing few local examples from which to draw inspiration during the design phase of the University of Windsor’s next generation learning spaces (NGLS).

The Design Process

A project with capital and human investment of this magnitude inevitably has a large number of stakeholders from varying backgrounds and disciplines. Designing a facility that allows for and facilitates not only the particular pedagogical paradigm of the organization, but also fulfils all the other practical and research needs of the faculty it houses is a complex and relatively high-risk venture. In order to provide representation from the major stakeholders, a multi-disciplinary and highly collaborative team was formed that encompassed architects from the University of Windsor and the firm designing the building (B+H Architects), engineering faculty members, technology specialists, and teaching and learning specialists, one of whom had experience in the design, implementation and support of faculty using new pedagogies for collaborative learning spaces. The team followed a process similar to that advocated by Haymaker and Chachere (2006) in designing Stanford’s new Living Laboratory Project, whereby Architecture, Engineering and Construction (AEC) professionals needed to communicate with other stakeholders to define goals, propose options, analyse the goals in respect to the options available, and make decisions to move forward. They note that this is a social process that requires the coordination of processes and information across a wide range of stakeholders, which is not something that AEC professionals are usually trained in, especially when dealing with stakeholders from specialist disciplines like education.
**Stakeholder Involvement**

Throughout the design and building phases, as well as during the phased occupancy, all stakeholders were kept informed of progress and developments as they happened. A number of stakeholder committees were struck to guide and inform various aspects of the project. These committees regularly reported back to the stakeholders. Town-hall style meetings were held and the architects, construction project managers and engineers were present to answer any questions as they came up. Focus groups with undergraduate and graduate students were held, and students were invited to all meetings. Feedback was genuinely taken seriously and incorporated into plans wherever possible.

**Environmental Scan**

One of the first tasks was to complete an environmental scan of recent next generation learning spaces (NGLS), and primarily those used in North American engineering and technology programs. The team visited the CDIO spaces within the Aeronautics and Astronautics Department at Massachusetts Institute of Technology (MIT), which is one of the originating organizations of the CDIO approach. The rationale for this space is to support the development of “engineering fundamentals within the context of the actual process engineers use: conceiving, designing, implementing and operating” (MIT, 2006). Team members also visited and consulted with staff involved with Queens University’s (Kingston, Canada) Integrated Learning Centre as a similar model, and investigated other spaces such as those used in the Student-Centred Activities for Large Enrolment Programs (SCALE-UP), which originated at North Carolina State University. One of the team members was also very familiar with design elements from NGLS projects in the UK, New Zealand and Australia.

**General Design Principles for NGLS**

There has been a fundamental shift in higher education pedagogies across all disciplines in the last two decades towards more collaborative approaches, driven largely by variations of constructivism theory and the ubiquitous nature of technologies that can support learning (Wilson & Randall, 2010). There is also growing recognition of the importance of *process* as well as *product* in learning, and a shift away from memorizing and regurgitating large amounts of content knowledge, to learning fundamentals of a discipline and applying them immediately. This shift has led to a rapid expansion over the last decade in the number of learning spaces designed specifically to support this pedagogical shift, which involves providing learning spaces with no fixed furniture, often no central podium, and access to technology.
While there are now a large number of these learning spaces in universities globally, there remains no definitive set of guiding principles or approaches to the design of these spaces, much less the evaluation of their outcomes, although recent projects in Australia (Radcliffe, 2008; Souter et al, 2011) and the UK (The Joint Information Systems Consortium (JISC), 2006) have provided some useful, evidence-based principles from which to start. The JISC report advocates for design that is:

- Flexible – to accommodate current and evolving pedagogies;
- Future proofed – the space can be reconfigured and re-used for other purposes;
- Bold – imagine new technologies and pedagogies;
- Creative – recognizing that the space itself can be inspiring and energizing for students and instructors;
- Supportive – the space provides for development of an individual’s potential;
- Enterprising – the space can support multiple purposes in the current configuration.

Siddall (2006) proposed eight guiding principles for learning space design:

- Learning spaces should support a diversity of learning styles;
- Learning spaces must be versatile;
- Learning spaces must be comfortable and attractive;
- Learning spaces are information rich and technologically reliable;
- Learning spaces must be maintained continuously;
- Learning spaces should be ubiquitous in space and time;
- Learning spaces should be used effectively; and
- Sufficient resources must be allocated for learning spaces.

Further, Long and Ehrmann (2005) proposed four key ideas to keep in mind when designing any learning space: learning by doing matters; context matters; interaction matters; and location of learning matters. Building on these ideas, they proposed a list of the characteristics of classrooms of the future:

- Designed for people not for ephemeral technologies;
- Optimised for particular pedagogies rather than filled with the latest technologies;
- Enabling the potential of technologies brought into the space, rather than fixing it into the space itself;
- Providing invisible technology and flexible use;
- Emphasising soft spaces;
- Able to be used 24hrs a day;
- Zoned for sound and activity.
What is common to all of these guidelines is a sense that NGLS should be flexible, easily reconfigured, with access to (expansible) technology, and focus on the human interaction elements of design such as comfort and attractiveness and different zones for different activities.

Radcliffe (2008) proposed a simpler model of Pedagogy-Space-Technology (PST) design and evaluation. Radcliffe argues that each of these elements, the core elements of any such project, influence each other in a reciprocal fashion. He also envisages this as an iterative model where pedagogy is the logical place to start the design, followed by the space, and then the technology. Radcliffe argues that the basic framework can be adjusted to fit any such project, and that ideally, there should be several iterations of the PST loop before a building is commissioned, and after commissioning in the review and evaluation stages.

The process of developing new spaces to fulfill these requirements has several phases, including bidding for new space and funding for such, the design phase, and the construction and commissioning phase. Wilson (2008) recognized the disconnect that often exists between those who teach in dedicated learning spaces, those who design those spaces, and those who incorporate technology into those spaces. We would argue that this disconnect usually also extends to those who provide curriculum and educational design support for instructors who have to utilise new spaces, and also to the upper management who ultimately make the decisions about what learning spaces will look like and include. Wilson (2008) suggests that this disconnect has traditionally led to inconsistency in quality, cost and outcomes of learning space design. He further argues that there is a role for an ‘educationalist/PST dramaturge’ who would essentially assist instructors and pedagogues in translating their pedagogical needs to language understandable by architects, engineers and technologists, and in turn, translating the language of these specialists to terms accessible by the educators.

Within the context of the present project, the University was fortunate enough to have two members of the design and implementation team who were able to fill a similar role. The multi-disciplinary team that worked on the project was able to develop a shared understanding of the broad needs of the project, along with developing a common language that allowed for productive discussions of the design elements that were considered critical to the success of the project.

**Key Design Elements of the Centre for Engineering Innovation**

The general guiding principles of designing NGLS identified above, along with the requirements of the CDIO pedagogical framework contributed to the development of the Centre for Engineering Innovation’s (CEI) design. These concepts were incorporated with a desire to build a facility that met the Leadership in Energy and Environmental Design (LEED) Canada NC v1.0 Gold Standards. LEED is a system for rating the design, construction and operation of high performance green buildings.
In addition to being a highly innovative and efficient building design, the CEI incorporates the “Live Building” concept that uses a wide range of sensors acquiring data from almost every aspect of the building itself. Table 1 lists the data that is available. This data can be integrated into and support active teaching and learning, and faculty research. Students and faculty will be able to visualize the collected data in real time and essentially have access to a large set of post-occupancy data on how the building is performing. This innovation means that the building itself becomes part of the tool for active and collaborative learning.

Table 1. “Live Building” features of the Ed Lumley Centre for Engineering Innovation.

<table>
<thead>
<tr>
<th>Live Building Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termobuild™ (concrete hollowcore terminal air delivery system)</td>
<td>temperature and air volume sensors to calculate losses and slab temperature (to measure thermal mass)</td>
</tr>
<tr>
<td>Roofing Thermal Gradients</td>
<td>temperature sensors to calculate losses through roofing layers</td>
</tr>
<tr>
<td>Wall Thermal Gradients</td>
<td>temperature sensors to calculate losses through wall layers</td>
</tr>
<tr>
<td>Biowall</td>
<td>temperature, humidity, CO₂, CO, and VOC sensors to calculate changes in air quality across the biowall</td>
</tr>
<tr>
<td>HVAC</td>
<td>air volume and velocity sensors to calculate duct losses</td>
</tr>
<tr>
<td>Weather Station</td>
<td>temperature, humidity, rain gauge etc. to measure weather patterns</td>
</tr>
<tr>
<td>Wind Anemometers</td>
<td>anemometers for wind mapping</td>
</tr>
<tr>
<td>Rainwater Harvesting</td>
<td>weir and flow monitor to calculate rainwater harvesting</td>
</tr>
<tr>
<td>Steam</td>
<td>temperature sensor and throttling calorimeter to measure steam quality</td>
</tr>
<tr>
<td>Domestic Hot Water Monitoring</td>
<td>flow and temperature sensors to measure hot water usage patterns</td>
</tr>
</tbody>
</table>

Designing for Accessibility and Collaborative Learning

Since the introduction of the provincial Accessibility for Ontarians with Disabilities Act (AODA), 2005, it has become law that all public institutions must ensure accessibility in physical and virtual spaces they control. Universal and accessible design is also consistent with the principle that space should be designed with human interactions in mind. The CEI was designed with these principles specifically in mind and the building is highly accessible using universal design (Mace, 1985; Preiser & Ostroff, 2001) with a combination of ramps, elevators and automatic doors. A major achievement in the design is a 350-person tiered classroom that is 60% accessible by wheelchair, which is almost unheard of in such spaces. This was achieved by having large spaces on each tier that allow for wheelchair access, ramp access and non-fixed furniture that can accommodate wheelchairs, as opposed to narrow walkways between fixed rows of chairs. It also allows groups to be configured quickly in a variety of sizes. The furniture design includes tables that can be either docked to the wall or reconfigured, along with moveable seating to support collaborative
learning activities. Also supporting this mode is a flexible technology backbone that includes microphones (to allow each pod to be heard over the room speakers), power and data at each table, extensive wireless network access, and enough bandwidth to allow for future expansion. This space is unique in that it is large enough for 350 seats, without the use of traditional fixed and tiered seating, and is reconfigurable to allow for interaction between groups. The space can be used for traditional lectures, small group work in a large class, studio teaching or a combination of these approaches and can be very quickly changed from one configuration to the next.

Figure 1 shows an architectural rendering of this space. The tables that facilitate collaborative learning among students and the reconfiguration of the layout can be seen.

Figure 1. Architectural rendering of the 350-person flexible classroom.

In addition to the larger lecture theatres, it was recognized that collaboration and collaborative learning can and should continue outside of the formal classroom. Students spend the majority of their time outside of the formal classroom and providing a space where they can remain on campus and work is rapidly becoming essential. No longer are students confined to computer labs to check their email or work on assignments; the rise of ubiquitous mobile devices means that they can now work and learn wherever there is access to the internet and electricity (although the latter is becoming less important as battery life of devices increases). Informal learning spaces can bring people together and provide a locus for serendipitous meetings, exploration, collaboration, discussion, and innovation (Oblinger, 2006).

Informal spaces that facilitate interaction between students, faculty, and researchers were designed into the building specifically to promote serendipitous collaborations. These spaces often include
comfortable lounges, and access to food services (Lomas & Oblinger, 2006). The CEI contains a large open space with its own café and informal lounge area equipped with wireless access, electrical outlets, natural lighting, information panels and seamless connections to the large classrooms on the first floor of the building so that students can drift out of the formal learning space directly into the informal (see Figure 2). This space is intended to be a hub of activity; noisy, connected and comfortable, and a place to foster the ‘conceiving’ stage of CDIO.

In addition to the less formal spaces, it is important to incorporate quieter spaces that provide locations for reflection or small group meetings. The CEI offers student-scheduled meeting rooms that are formal collaboration spaces equipped with tables, comfortable seating, internet and electrical access, projectors and whiteboards. These spaces cannot be scheduled by faculty (they cannot be used for formal classes), are primarily for student use, and are designed to facilitate the ‘design’ component of CDIO pedagogy. On the upper floor there is also a large open plan space for graduate students, faculty offices, and a green roof terrace where students and faculty can meet, interact, and collaborate. These spaces were designed with the needs of students in mind. They provide locations for meetings, studying, socialization, and collaboration. They are also flexible enough that students can decide how they want to use each of the spaces.

Table 2 summarises the key design elements of the spaces available in the CEI, their intended use, and what part of the CDIO pedagogy they support. All elements of the CDIO approach are catered
for within the building, and there is a strong emphasis on collaboration and social aspects of learning that more traditional spaces did not provide.
Table 2. Summary of spaces and their intended uses in the CEI.

<table>
<thead>
<tr>
<th>Space</th>
<th>CDIO or other element supported (C = Conceive, D = Design, I = Implement, O = Operate; B = basic knowledge acquisition; S = Social interaction)</th>
<th>Potential activities supported</th>
<th>Key design features</th>
</tr>
</thead>
<tbody>
<tr>
<td>350 seat space</td>
<td>B, C</td>
<td>Lecture, group work, seminar, webinar, studio teaching</td>
<td>Accessible (60%), flexible seating, docking tables, reconfigurable, tiered, large bandwidth, extensible, microphones, data and power at pods, wireless, multiple projectors/screens, central fixed control console, floor space large enough to drive vehicle into the theatre</td>
</tr>
<tr>
<td>2 x 120 seat spaces</td>
<td>B, C</td>
<td>Lecture, group work, seminar, webinar</td>
<td>Wireless, data, power, fixed seating, tiered, some accessible seating, central fixed console, auditorium style</td>
</tr>
<tr>
<td>40 seat spaces</td>
<td>C, D, B, S</td>
<td>Lecture, group work, seminar, webinar, studio teaching, collaboration, reflection, group study</td>
<td>Accessible, flexible seating, moveable furniture, white boards, moveable console, wireless, power</td>
</tr>
<tr>
<td>Research labs</td>
<td>D, I, O</td>
<td>Specialised research equipment for designing and building engineering outputs</td>
<td>Flexible and specialised, accessible</td>
</tr>
<tr>
<td>Student labs</td>
<td>D, I, O</td>
<td>Specialised equipment for designing and building engineering outputs</td>
<td>Flexible and specialised, accessible</td>
</tr>
<tr>
<td>Student collaboration rooms</td>
<td>C, D, B, S</td>
<td>Formal meetings, quiet reflection, social meetings, project collaboration, group study</td>
<td>Wireless, power, table, comfortable moveable chairs, whiteboards, natural lighting, projectors, sound dampening, comfortable, bookable by students, accessible</td>
</tr>
<tr>
<td>Graduate student office</td>
<td>C, D, B, S</td>
<td>Collaboration, reflection, quiet work, tutoring, mentoring</td>
<td>Open plan, lockable pods/desks, natural light, comfortable, accessible</td>
</tr>
<tr>
<td>Green roof terrace</td>
<td>C, S</td>
<td>Social interaction, collaboration, meetings</td>
<td>Natural lighting, comfortable, accessible, open space, grass and trees, hidden drainage, novel space</td>
</tr>
<tr>
<td>Foyer/lounge</td>
<td>C, D, B, S</td>
<td>Social interaction, collaboration, meetings, information gathering, serendipitous meetings, interaction with faculty and students, food, quiet reflection, personal and group study, information</td>
<td>Natural lighting, comfortable seating, tables, café, wireless access and power, accessible, noisy, information screens, accessible, large open space, flows from large classrooms and through to the outside spaces</td>
</tr>
<tr>
<td>Corridors/Expanded Bridge Lounges</td>
<td>C, B, S</td>
<td>Social interaction, collaboration, meetings, information gathering, serendipitous meetings, interaction with faculty and students, quiet reflection, personal and group study</td>
<td>Natural light, flexible seating, wireless and power</td>
</tr>
</tbody>
</table>
Preparing Faculty for the New Building

Lomas and Oblinger (2006) argue that providing a space that specifically supports a desired pedagogy will likely lead to its uptake; a pedagogical ‘build it and they will come’ approach. The new building offers myriad ways in which pedagogy, space and technology can interact to enhance student learning, engagement and satisfaction. The building design focused on making supporting collaborative and active learning; however, if the faculty tasked with teaching in these spaces are unfamiliar or resistant to collaborative and active learning pedagogies, then the spaces will fail in their intended purpose. Some faculty are early adopters or able to take abstract information and apply it to a practical teaching setting (Rogers, 1995). Others will resist any and all change vehemently, and for those with tenure, there is little incentive to make changes to long-standing practices. In either case, providing professional development and ongoing support to instructors using these new learning spaces are key to successful implementation. At the same time, students may also struggle to learn in new ways afforded by the spaces and pedagogical changes, so their needs must also not be ignored.

Faculty Development

Faculty development is necessary whenever pedagogical change is a goal, but is particularly important when major changes are desired or required. The multi-disciplinary stakeholder committee tasked with facilitating this change met regularly throughout the design and construction phases to plan events and activities that were intended to lead to the sort of pedagogical change deemed necessary and made possible by the new building. The plan included developing a series of workshops during the pre-occupancy phase, providing individual consultations, broader curriculum planning where needed (at the course and program level), and a series of post-occupancy workshops and events demonstrating different uses of the spaces and technology, including brown-bag lunch discussions that were planned to occur in the informal spaces.

A series of workshops were planned, with each to focus on different aspects of using the new learning spaces. Faculty from Engineering and the other departments who regularly teach in the engineering programs (maths, physics, computer science) were personally invited to attend the workshops. The first workshop, held in February 2012, provided an overview of the architecture of the new facilities, focusing on the learning spaces. The attendees were encouraged to ask questions and reflect on how the spaces could be used for teaching. Examples of uses of similar learning spaces around the world were provided. The workshop facilitators also modelled some basic uses of flexible learning spaces by reconfiguring furniture in the workshop space and using different approaches to facilitation. It was clear at the end of this workshop however that changing faculty attitudes and behaviours would require a sustained effort to demonstrate the benefits of making such changes. Many had struggled to move beyond an abstract idea of what the learning
spaces would contain at a micro-level (such as locations of garbage bins, custodial support, lighting, access after-hours etc.) and could not envisage either the new spaces or how they might be used.

For the second workshop, in March 2012, it was decided to bring in an external expert in collaborative learning in the STEM disciplines, Dr. Bob Beichner, from North Carolina State University. The team believed that an external facilitator with high standing and credibility would be likely to make more impact than local facilitators, especially if he reiterated some of the points made in the previous workshop. Dr. Beichner facilitated a workshop on active learning and the SCALE-UP (Handelsman et al, 2004; Beichner, 2007) framework. Dr. Beichner demonstrated various active learning activities by making the attending instructors work through as those activities. These were explained as activities characteristic of active learning approaches that have been highly successful in improving the performance of students in undergraduate physics courses. These activities provided concrete demonstrations of how active learning can be implemented within a course, and how the configuration of the classroom can be manipulated to facilitate active learning.

Once the building was occupied, small targeted workshops were offered by audiovisual technicians to instructors who were planning to teach in the classrooms. The instructors were able to observe and try using the equipment. These small workshops were offered at the beginning of each term.

The third major workshop, (not yet completed at the time of writing), will also feature an internationally renowned facilitator. The workshop aims to develop a deeper understanding of the relationship between pedagogy, space and technology in active and collaborative learning environments (Radcliffe, 2008). The workshop will demonstrate ways in which the existing space can be used to improve learning. The importance of constructively aligning (Biggs, 1996) learning outcomes, teaching and learning activities, and assessment practices within a course will be integrated. The event will also include three shorter concurrent sessions through which the attendees will rotate, gaining experience in different aspects of the building’s design and appropriate pedagogies for those spaces. Topics will include experimenting with the technology available in the classrooms and good practices for its use, the features of the Live Building and the data available, and potential roles for graduate assistants and teaching assistants in active and collaborative classes. Instructors from the institution who have tried effective ways of using the space will be invited to contribute.

In addition to these workshops, there is a plan to implement regular ‘brown-bag’ discussions in the flexible and informal learning spaces. These will ideally be driven and facilitated by faculty and graduate students (primarily from engineering, but open to other disciplines) with support from academic developers. The intention is develop a faculty learning community to facilitate a strong scholarly approach to the use of the new spaces (Cox, 2003, 2004; Warhurst, 2006). We anticipate that this learning community will develop over time from what Cox (2003) describes as a topic-based learning community (one that comes together to address a particular, narrowly focused issue.
or challenge) to a cohort-based learning community (one that is driven by development needs of a particular group of faculty, i.e. users of the CEI and those who teach into engineering programs more broadly). Successful change will also undoubtedly require support and development at the individual level, as advocated by Warhurst (2006). If faculty are able to not only buy into the pedagogical changes being implemented, but also to feel as if these changes are making a difference, they are more likely to persist with the change and achieve better outcomes (Warhurst, 2006).

**Post-Occupancy Evaluation**

Post-occupancy, surveys were administered to students to evaluate their attitudes towards the effect of the CEI learning spaces on their learning. A copy of the survey is included in Appendix 1. Results of the survey, which was administered to select classes of students in the Winter 2013 and Summer 2013 semesters, are shown in Figures 3 – 7. The classes were selected in order to survey students in various years of their education and in various classrooms.

The post-occupancy survey was delivered to students in the large 350-person classroom, the 120-person fixed seating classrooms, and the flexible 80- and 40-person classrooms. A total of 11 classes participated, with 322 students responding. The survey results indicate that students at all levels of their program responded (Figure 3).

![Figure 3: Number of students at each year level responding to the survey.](image)

Figure 3: Number of students at each year level responding to the survey.
When students were asked to compare their experience in the new CEI building with their learning experience in other classrooms in the University, CEI spaces were rated consistently higher (Figure 4).

Figure 4: Student rating comparing CEI to non-CEI classrooms: Average rating for questions 1 – 13 in Winter 2013 and Summer 2013 combined.

Figure 5 examines the average student rating difference between CEI and non-CEI classrooms, looking at all students combined (W13 and S13), as well as looking at the two cohorts separately. The second cohort surveyed in the summer (S13) had a greater difference in ratings, rating the CEI spaces more positively.
Figure 5: Average student rating difference [(CEI) – (Non-CEI)] for questions 1 – 13.

Figure 6 examines the average student rating on questions that asked about the ways in which the classroom was used to support learning, and what they believed about learning. The average rating for each cohort separately was very similar to the combined averages.
Survey results indicate that students at various year levels responded (Figure 3) and, students perceived that CEI learning spaces contributed towards their learning, compared to non-CEI learning spaces (Figure 4), with a greater difference between the rating of CEI versus non-CEI learning spaces during the Summer 2013 semester (Figure 5). The higher ratings given in the summer may be due to the fact that during the Winter 2013 semester, some of the technology and logistics of moving into the new learning spaces was not "ironed out", since it was the first semester of use.

The average rating for questions 14 to 25 (Figure 6) was 3.60, indicating that the majority of students were on the “agreeing” side of “neutral” to questions relating to the ways in which the learning spaces support their learning. This suggests a positive experience, but suggests that there is room for continued enhancement in the ways that the CEI spaces are used to support learning.

Finally, for the Yes-No questions (Figure 7), the majority of students responded “Yes” that the CEI learning spaces enhanced their learning experience; however, the majority also responded “Yes” that they had experienced some challenges. These challenges included many things such as problems hearing due to echoes in some classes (particularly the 80-seat classrooms), an inability to access the learning spaces 24 hours a day, and whiteboards that are not able to be erased well.
The Faculty of Engineering is currently working to address these issues by retrofitting certain rooms with improved sound abatement, investigating different options for student access and security for the CEI, and installing new whiteboards that can be more cleanly erased.

**Figure 7:** Student response: Yes-No count by semester for questions 26, 27, 28, and 30. (26. Do you believe the CEI classroom you are currently in has enhanced your learning experience? 27. Overall, do you believe having classes in the CEI has enhanced your learning experience? 28. Have you experienced any challenges while using the CEI that have impacted on your experience in the learning spaces? 30. Do you believe workforce readiness is an important aspect of your education?)

**Conclusion**

The successful process of designing, building and occupying a new facility requires commitment from a wide range of stakeholders who would not normally work closely together. The CEI building at the University of Windsor intentionally designed learning spaces to meet the needs of the Engineering including CDIO, universal design for accessibility and sustainability. These were integrated together with principles for new generation learning spaces. To do this, members of faculty from across the Faculty of Engineering were involved in addition to the Assistant Provost,
Academic Architectural Advisor, members of the CTL and B+H Architecture. This interdisciplinary process in itself builds connections within and beyond the University that will likely be ongoing and lasting. The building design has incorporated features suggested by many individuals and groups.

When creating spaces that help to facilitate active and collaborative learning, it is critically important to gain buy-in from faculty and instructors who will be using these spaces. The workshops facilitated so far have provided the faculty with ideas, suggestions, and examples of ways in which the new learning spaces can be used for collaborative and active learning. This is not enough to change long-held beliefs and practices however, and so focussing development work at the individual faculty-member level is also important in the early stages of curriculum change. The support needs to be ongoing after occupancy of a building to help support the transition to new ways of teaching and learning. A post-occupancy survey of students indicates that they perceive a benefit to their learning due to the learning spaces provided by the CEI. The feedback from the students is useful to provide ongoing enhancement of the new spaces. As similar projects to re-envision new generations of learning spaces are becoming more common in higher education, the process undertaken here can provide a useful framework for projects.

Acknowledgements

We would like to thank the Dean of Engineering, Dr. Saif; the Dean’s Office, Lorraine Grondin and Shelby Marchand; and staff and faculty in Engineering for their support in the project. Additionally, we would like to thank the Centre for Teaching and Learning for a special grant in the support of the Learning Spaces project.

References


Mace, R. *Universal Design: Barrier free environments for everyone*. Los Angeles: Designers West.


Appendix 1: Student Survey to Understand the Effect of CEI Learning Spaces on Student Learning

SURVEY

Please answer the following survey as completely as possible. The information that you provide will help us to evaluate the effectiveness of the learning spaces within the Centre for Engineering Innovation (CEI). Thank you in advance for completing this survey.

Demographic Information

Gender: _________
Age: _________

In what department are you a student?

☐ Civil & Environmental Engineering
☐ Electrical & Computer Engineering
☐ Industrial & Manufacturing Systems Engineering
☐ Mechanical Engineering
☐ General Engineering
☐ Other (please specify) ________________________

What year level are you currently studying?

☐ 1st Year
☐ 2nd Year
☐ 3rd Year
☐ 4th Year
☐ Masters
☐ PhD

Have you attended school outside of Canada?

☐ No  ☐ Yes  If yes, how many years?___________

For what course are you responding to this survey:

Course #___________  Section#_______
Semester __________

In what room is the above course located:

Room #____________
Part 1. The Classroom
For each statement, please think about other classrooms on the University of Windsor campus you have had classes in, and indicate in the “NON CEI” column your responses to the questions as they relate to that classroom. Next, think of CEI classroom you are currently in and indicate your responses to the questions as they relate to this classroom in the “CEI” column.

Please use the following scale when answering the statements:
(1) Strongly disagree;
(2) disagree;
(3) neutral;
(4) agree; or
(5) strongly agree.

Comparing the ‘CEI’ classroom with other ‘Non-CEI’ classrooms you have been a learner in, please rate each of the following:

<table>
<thead>
<tr>
<th>Statement</th>
<th>CEI classroom</th>
<th>Non CEI classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is easy to reconfigure the classroom for different class activities (i.e., teamwork, group discussion, lecture, etc.).</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. The configuration of the classroom helps me to concentrate on the class activities (i.e., teamwork, group discussion, lecture, etc.).</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. The configuration of the classroom helps me stay oriented to the instructor, projection screen, and other students.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4. The configuration of the classroom helps me to participate during class.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5. The configuration of the classroom positively impacts my overall learning experience.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6. The configuration of the classroom enables me and my classmates to efficiently tackle the work required for the class.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>7. The configuration of the classroom helps keep me motivated to achieve my goals for this course.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>8. The classroom enables my instructor to provide various learning opportunities</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>9. The classroom supports the way I learn best (i.e., seeing, hearing, and/or doing).</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>10. The classroom is comfortable.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>11. I can hear the instructor and my classmates clearly during discussions in the classroom.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>12. I can see the instructor clearly no matter where I sit in the classroom.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>13. The learning space positively influences my engagement in the course.</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
**Part 2. Your courses**

The following questions relate to the way in which the classroom is used to support learning, and what you believe about learning.

Please use the following scale when answering the statements:
(1) Strongly disagree;
(2)disagree;
(3) neutral;
(4) agree; or
(5) strongly agree.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>14. Collaborative work (e.g., teamwork, group discussion) is emphasized in my engineering classes.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. I believe that collaborative work provides a high level of academic challenge.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. I am confident that active participation in class will help increase my knowledge of the subject matter.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>17. I am confident that active participation in this class will help me obtain a higher course grade.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>18. I believe my experience in this class will improve my readiness for the workforce.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. The instructor in this course places a high priority on engaging students.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. I receive more attention from the instructor through the methods used to teach this class compared to other classes.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. I have had meaningful interactions with the instructor and other students in this class.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. I received meaningful and timely feedback from the instructor in this class.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. I enjoy coming to class.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. I enjoy participating in class.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. I felt I learned a lot from this class.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part 3. Open questions

26. Do you believe the CEI classroom you are currently in has enhanced your learning experience?
   ☐ Yes  ☐ No
   Please explain:
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

27. Overall, do you believe having classes in the CEI has enhanced your learning experience?
   ☐ Yes  ☐ No
   Please explain:
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

28. Have you experienced any challenges while using the CEI that have impacted on your experience in the learning spaces?
   ☐ Yes  ☐ No
   Please explain:
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

29. What changes do you believe would make the CEI learning spaces more effective in helping you learn?
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

30. Do you believe workforce readiness is an important aspect of your education?
   ☐ Yes  ☐ No
   If so, how do you believe the CEI learning spaces will contribute to your workforce readiness?
   __________________________________________________________
   __________________________________________________________
31. How have you used the informal (i.e. non-classroom) spaces in the CEI?
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

32. Which of the informal spaces do you most like using and why?  
   Please explain:
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________