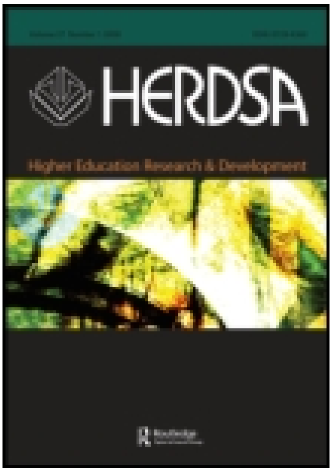

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Transforming the twenty-first-century campus to enhance the net-generation student learning experience: using evidence-based design to determine what works and why in virtual/physical teaching spaces

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The twenty-first century has seen the rapid emergence of wireless broadband and mobile communications devices which are inexorably changing the way people communicate, collaborate, create and transfer knowledge. Yet many higher education campus learning environments were designed and built in the nineteenth and twentieth centuries prior to wireless broadband networks. Now, new learning environments are being re-engineered to meet these emerging technologies with significant challenges to existing pedagogical practices. However, these next generation learning environments (NGLEs) have not been evaluated thoroughly to see if they actually work as they are scaled up across the higher education system. Whilst there have been a range of NGLEs designed globally – with Australia leading in the past five years or so – it is timely that a more rigorous research methodology drawing from health facility evidence-based design is taken to evaluate their effectiveness in improving the student experience and learning outcomes.

Keywords: evidence-based design; learning environments; learning space evaluation; pedagogy; student experience; TEAL; university design

The impact of the virtual on the physical

The recent advent of wireless broadband internet access and mobile, hand-held, communications devices has not only provided remarkable opportunities for twenty-first-century blended learning models – simultaneously online and face-to-face – but has seriously called into question the efficacy of the still pervasive industrial-age 'egg-crate classroom' model of teaching and learning.

It also has enabled a true synchronous/asynchronous and virtual/physical matrix of learning opportunities to emerge for which our existing learning environment infrastructure is not well suited (Mitchell, 2003) (Figure 1).

As a response to these developments many innovative learning environments are being trialled. This includes an increasing focus on the so-called third space to support informal and social forms of student interaction to enhance the student experience and improve learning outcomes.

Mitchell's (1996) City of Bits has proved to be an accurate predictor of the impact of information and communication technologies (ICT) on learning. With the advent of Massive Online Open Courses (MOOC) and multi-national and multi-campus

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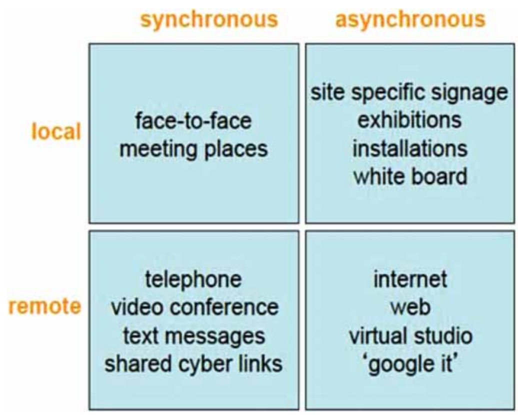

Figure 1. Virtual/physical matrix.
Source: Mitchell (2003).

universities (Gallagher & Garrett, 2012), it will not be long before a Harvard or Oxford degree can be obtained through a hybrid virtual/physical experience campus, both online and on multiple off-shore campuses.

A key research question then is 'to what extent is a physical campus still relevant?' If it is still relevant, what physical attributes need to be provided to encourage students to actually attend campus and to meet face to face with their colleagues, rather than solely through social networking tools? Furthermore, many of our built learning environments were designed for nineteenth- and twentieth-century pedagogies with computers mainly being used in the computer laboratory. With wireless connectivity, most spaces on campus can equate to a computer lab.

Interestingly, many of these emergent spatial developments in formal learning environments are being instigated through initiatives led by ICT departments, particularly in universities, and also now in further education and schools (Educause, 2012; JISC, 2006; Scottish Funding Council, 2006). In parallel to the re-engineering of these formal learning spaces is a profusion of informal learning commons, learning hubs and student centres to encourage students to spend longer hours on campus with their peers (Fisher, 2003).

The research questions, gaps in literature and research methodologies

These developments are blurring the boundaries between what has traditionally been seen as the 'built learning environment' and the associated ICTs that support those spaces. There is also the tension between 'distance learning' or online MOOC and the on-campus use of e-learning in a face-to-face context – hybrid/multi-modal learning. The rapidly emerging models of 'technologically enhanced learning environments' (Technology Enabled Active Learning [TEAL]) – first introduced under that term at the Massachusetts Institute of Technology (MIT) in 2000 – emphasise the role that acoustics, furniture, lighting (both natural and artificial), mobility, flexibility, air temperature and security have in supporting the new and emerging educational technologies designed for those spaces.

Now that these technologies are widely available and increasingly affordable, a broader range of pedagogies are emerging, or at least can be more readily practised.

The 'family of learning styles' (categories by Coffield, Moseley, Hall, & Ecclestone, 2004) suggests these might fall into five typologies: preferences (1) are largely *constitutionally* based including the four modalities (VAKT, i.e., visual, aural, kinaesthetic and tactile); (2) reflect deep-seated features of the *cognitive structure*, including 'patterns of ability'; (3) are one component of relatively *stable personality types*; (4) are *flexibly stable learning preferences* and (5) evolve from learning styles to *approaches, strategies, orientations* and *conceptions* of learning.

Students are learning collaboratively in a wide array of both formal and informal learning spaces, on and off campus, yet are often still crammed into these outdated industrial-age classroom models. As the knowledge age morphs rapidly into a creative age, classrooms, students tell us, are the least creative space they can learn in (Fisher, 2002). We also need to acknowledge the extraordinarily rapid advances in social networking such as Twitter, Facebook and Pinterest, to name but a few, which can all be used in learning frameworks (Educause, 2012).

Our relatively rigid learning spaces must adapt to meet the emerging needs of a wide range of pedagogies for a variety of subject disciplines.

Staff and students have only a limited ability to improve the affordance (Gibson, 1977) of nineteenth- and twentieth-century learning spaces and so it is up to the institution to support this transformation, as illustrated in Figure 2. In order to better understand these issues, the important research questions are thus the following:

(1) What are the key graduate competencies/attributes being sought by employers, professional associations and research bodies, how should they be 'taught' and what does this mean for the physical and virtual learning environment?
(2) How is social networking and the virtual community impacting on the face-to-face campus student experience?
(3) Where are the world's best exemplars of the hybrid campus and what are the key elements that make these successful?
(4) What are the successful emerging teaching, learning and research approaches in the twenty-first century, especially combining synchronous campus-based online, face-to-face/hybrid and multi-modal experiences?
(5) What are the key academic attributes of a successful campus-based lecturer in the twenty-first century?

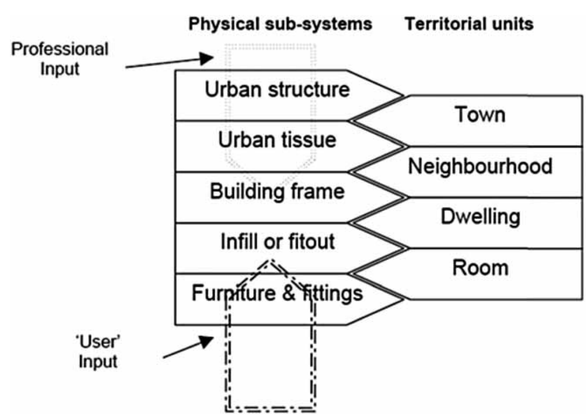

Figure 2. User input into facilities design (Habraken, 1998).

In understanding the discourse in relating these competency/attribute issues to space, place, technology and pedagogy, there is a significant gap. The *Journal of Learning Environments* rarely, if ever, includes critical articles on the physical, let alone the tension between the virtual and physical learning community. A recent literature review on the subject (Cleveland & Fisher, 2014) found that there was a significant gap in understanding the links between space, place, pedagogy and ICTs. This finding is supported by another significant literature review entitled *Research into the connection between built learning spaces and student outcomes* (Blackmore, Bateman, Loughlin, O'Mara, & Aranda, 2011). This makes establishing an effective research methodology to address the research questions a significant challenge.

We have explored the evidence-based design approach which is practised in health facility planning. This is an emerging discipline derived largely from the translational research medical model used in pharmaceutical trials (Translational Research, 2014). Such trials ensure that the resultant evidence is sufficient to ensure the safety of the drug under test for use with patients. This evidence-based approach has been adapted to health facility design with quantitative and qualitative studies measuring the rate of healing of patients in different physical environments. Also known as translational design (Norman, 2010), these studies follow similar research methodology rigour used for drug trials and are resulting in convincing evidence of the impact of the physical environment on human behaviour as outlined in another literature review *The role of the physical environment in the hospital of the twenty-first century* (Ulrich, Xiaobo, Zimring, Anjali, & Choudhary, 2005).

Such evidence-based research methodologies need to be leveraged into learning environment evaluation. Some quantitative and qualitative measures have been trialled to provide measures for supporting the design of learning environments. However, the results are so far of limited rigour, with a focus on environmental/technical issues such as lighting levels, acoustics and air quality. One of the dilemmas of quantitative research is the challenge of the reduction of complexity to a focus on that which is measurable. Fixing variables is difficult in such studies as, for example, what is the impact on student learning of 'good teaching', student motivation (related to a number of factors including socio-economic background), quality and equity of technology, to name but a few.

The question we are asking is how quantitative and qualitative measures can be interlinked to throw further light on the benefits of learning space design on learning outcomes for tertiary students. The question is not straightforward as qualitative methods belong within a conceptual framework which is largely at odds with the paradigm used by quantitative researchers. The assumptions about what constitutes knowledge and the means for generating knowledge are often incommensurate (Morgan, 2006). Rather than mix paradigms, the authors suggest using some quantitative methods within a qualitative framework recognising that questions concerning learning space design must necessarily involve issues such as power, ethnography and socio-economic circumstances.

Emerging teaching and learning methods – the emergence of collaborative and team-based learning in the physical and virtual learning space

With increasing reliance by students on virtual learning spaces we need to understand the altered role of the physical campus. A recent edited compilation on virtual and physical learning environments by Keppell, Souter, and Riddle (2012) presents a suite of

	%	***Graduate capabilities CDIO/Engineers Australia***
1	26	Personal skills and attitudes/professional attitudes
2	19	Communication – ability to communicate effectively
3	17	Designing – proficiency in engineering design
4	14	Teamwork – ability to function effectively as an individual, and in multidisciplinary and multicultural teams
5	12	Systems thinking – ability to use a systems approach to complex problems, and are designed and operational performance
6	12	Conceiving and designing engineering systems – ability to utilise a systems approach to complex problems

Figure 3. Top six graduate capabilities as represented by www.CDIO.org and Engineers Australia.

case studies showing explorations being undertaken at several tertiary campuses. There is still little consensus about what will be required of the future campus within evolving virtual learning environments. We assume there will continue to be benefits for students meeting with each other and their educators within environments that are richly connected to digital and physical social spaces.

A critical term in understanding the future of effective teaching and learning is to engage with the concept of discipline-specific graduate attributes or competencies. For engineers these might include critical thinking; communicating with peers and the wider community in a range of modalities; working in multi-disciplinary teams; environmental literacy and civic understanding. (Refer to Figure 3 for the percentage of respondents who favoured specific competencies.)

Engineers are involved in complex projects – particularly around infrastructure – which means they will be working across and in collaboration with a range of disciplines. To continue to learn in an explicit teacher-centred way will not afford students with that broad range of competencies.

This was first understood in the teaching of medical students. For some 30 years medicine has been taught in a collaborative way with groups of 10 students addressing authentic problems supported by a tutor. This model is difficult to achieve across all university disciplines because of cost limitations, but the approach can be modelled using the TEAL concept. What has not yet emerged is a learning environment typology that matches these graduate competencies, although this is often required in the accreditation criteria of many disciplines, for example, engineering and business. These learning space typologies need to align with the pedagogical practice and learning modalities proposed to support the achievement of those competencies.

Engaging with multi-modal and hybrid learning – the student experience and graduate attributes/capabilities/competencies in the physical and virtual space

A learner-centred collaborative learning model is becoming increasingly relevant due to the impact of wireless broadband technologies. As information is increasingly accessible to students, the role of the teacher has changed from the more explicit twentieth-century model of lectures supported by tutorials to environments where students are active learners taking more responsibility for their own learning. Increasingly, the complexity of twenty-first-century problems requires us to work across organisations and discipline boundaries. The seemingly intractable problems of the environment, globalisation, energy, water, urbanisation and human rights cannot be solved within one disciplinary framework.

TEAL environments support a collaborative approach to teaching and learning, including peer-to-peer learning:

> Collaborative learning means students are engaged in the completion of a common task. Students are not only in groups, they work together in groups, playing a significant role in each other's learning. The collaborative learning process creates a shared understanding of a topic and/or process among a group that members of the group could not achieve alone. Students may work face-to-face and in or out of the classroom, or they may use information technology to enable electronic discussion or collaborative writing tasks. (University of Adelaide, 2012, p. 3)

Collaborative learning focuses on the learning aspect of working together, whereas group 'teaching' focuses on what the lecturer does, rather than on students taking responsibility for their own learning in collaboration with others. Nagata and Ronkowski (1998) describe collaborative learning as an umbrella term encompassing many forms from small group projects to the more specific concept of 'cooperative learning'. Students benefit by exploring the logic of their own thinking and beliefs against those of others. Cooperative learning tends to be teacher facilitated, whilst collaborative learning can be in informal spaces, often focusing on a group project without an instructor present. Furthermore, it can occur online, in a laboratory, in the field or in a classroom:

> The problem to be solved is an example of the types of problems found in the community, in industry or in commerce; the solution to the problem requires the use of knowledge, skills and attributes that are part of the curriculum; the problem can be solved by a small team of students, none of whom possesses the knowledge or skills to solve the problem alone, yet each of whom is able to contribute to the final product. (Miller, Imrie, & Cox, 1998, p. 162)

Although the original TEAL model discussed below was launched in 2000 to rejuvenate the teaching of Physics 1 at MIT, many versions of it have since proliferated in geology, chemistry, engineering, education and architecture. It is in engineering, however, that the most significant variations and advances have been made and this is largely because of the need for graduate engineers to have a much wider range of graduate competencies than can be assessed solely in the examination room:

> These questions are important to engineering education because engineering schools are preparing students who, as professional engineers, will be required to work in self-directed ways through problem solving and collaborative teamwork. (Chang, Stern, Sondergaard, & Hadgraft, 2009, p. 2)

MIT also initiated a new engineering pedagogical model in its aeronautical school called CDIO – conceive, design, implement and operate. This integrated discovery, authentic and active learning approach has now rapidly expanded across the globe (CDIO, 2012).

Case studies

Four case studies are considered here to evaluate the effectiveness of these TEAL prototypes: (1) the Australian Science and Mathematics Years 10, 11 and 12 Senior

Secondary School located on the Flinders University Campus; (2) Experience 1, the 1st Year Collaborative Learning Centre of the Faculty of Engineering of the University of South Australia (UniSA); (3) the fourth-year and doctoral/industry computer science design collaborative of the Engineering Faculty of the University of New South Wales; and (4) the University of Melbourne engineering collaborative years 1–5. Figure 4 outlines a comparative summary of key aspects of each project and approach.

The Australian Science and Mathematics School (revisited)

Opening in 2003 this school has been featured in many publications and visited by hundreds of state, national and international groups as it was designed to reflect and support what was then, for schools, a 'radical' comprehensive problem-based pedagogical approach. It has no classrooms so students use learning commons and the laboratories are rebranded as 'learning studios' adjacent and permeable with the learning commons.

Responding to the findings of the Australian Chief Scientist's Report (Batterham, 2000) on the reducing uptake by students of science and maths in senior schools, universities, research and professional school undergraduate teaching programmes, the school is a partnership between the South Australian Education Department and the Dean of Science of Flinders University. The Batterham findings had been exacerbated by the teaching of maths and science in schools by teachers not holding tertiary qualifications in science and maths, so the dean approached the Education Department to see what could be done about this issue. A subsequent study (Chubb, 2012) suggests that

No.	Case Study	Cohort Sizes	Group Sizes	Educational Technologies	Educational Philosophy	Student motivation	Teacher practice
1	Australian Science & Maths School, Flinders Uni (senior secondary 10-12)	25, 50, 75, 100	2,3,4,5, 6,8,12	Laptops, shared flat screen desktop, group LCD screens, data projectors	Problem-based learning; new sciences; completely new curriculum with Univ Science Fac.	Selected by interest in maths & science interview, not test scores	High teacher professional learning; S.A. centre of excellence for Science & Maths
2	Experience One, Engineering, UNISA	50, 100	2,3,4,5, 6,8,12	Laptops, shared flat screen desktop, group LCD screens, data projectors	Problem-based; peer tutors; student experience & retention; engineering community	Social inclusion in Adelaide north; 2nd & 3rd years as tutors wanted to use space	Online embedded curriculum; peer mentors; team-based projects
3	4th Year Computer Engineering, UNSW	96 u/gr 30HDR	2,4,8	Laptops, shared flat screen desktop, group LCD screens, data projectors	Doctoral & industry collaboration; engineering community; final year project	Research with industry on shared project; doctoral influence as possible future trajectory	Very high motivation of one academic who was ALTC Discipline Leader
4	Engineering, Univ Melbourne	60	3, 6	Laptops, shared flat screen desktop, group LCD screens, data projectors	CDIO / TEAL combined; revamped curriculum; engineers as designers, engineering community	High nos international students; high TER; >75% RHD internationals; language issues	High motivation re design and engineering graduate attributes; pioneers of TEAL

Figure 4. Summary of key comparators and elements in case studies.

there has been little change nationally, despite the efforts of the Australian Science and Mathematics School (ASMS).

Key features of the ASMS include the following: years 10, 11 and 12, focused on problem-based learning around maths and science and located on the Flinders University Campus; the curriculum is designed and delivered in partnership with the university science faculty; the school acts as a professional development centre with attendees from across the nation and also internationally; and the use of 'learning commons' and 'learning studios' was adopted, breaking away completely from the traditional classroom. These elements are co-located to foster seamless theory and practice learning. The desks in the learning commons are organised by the students to suit their negotiated social, formal and informal learning needs.

School students also host visitors and teachers attending continuing professional development programmes and explain how the school works. Figures 5 and 6 illustrate the pedagogical framework and the non-institutional 'feel' of the school. The school was planned around the CDIO concept (this concept was emergent at the time).

A study of the effectiveness of the ASMS in delivering learning outcomes is the subject of a number of doctoral dissertations at the time of writing. One metric of interest is that 90% of graduate students from the ASMS enter university, an excellent result indeed given the original aim of the ASMS, Flinders University's Faculty of Science and the State Department of Education and Children's Services. Based on the success of the ASMS, similar schools have emerged particularly in Victoria including the John Monash School at Monash University, the Gungahlin Senior Secondary College in the Australian Capital Territory, and the Hume Central Secondary College and the Gustav Nossel Special Select School, both of which are in Victoria.

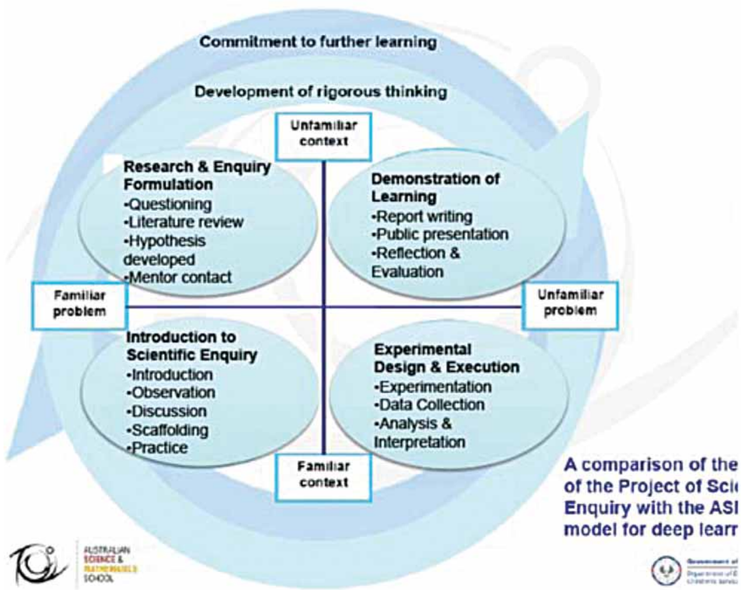

Figure 5. The ASMS pedagogical framework.
Source: ASMS.

Figure 6. ASMS informal learning area, a studio and the commons.
Source: Woods Bagot.

Critically these should be rigorously evaluated if they are to be replicated across systems in various states of Australia.

In Australia, universities will soon be seeing the results of the federal government's schools laptop programme and the emerging flexible learning centres in senior secondary schools as the graduates of these schools arrive at universities expecting to experience twenty-first-century learning environments. In particular, there are variations on the generic TEAL approach emerging for specific disciplines as it evolves to meet the particular needs of the various subjects and their range of pedagogies.

In evaluating teachers' learning at the ASMS, a recent doctoral graduate found significant connections between the pedagogical process and the flexibility of the ASMS school design (Bissaker, 2010). Eight of the teachers at the ASMS have enrolled in Ed. D. programmes and a research project is underway by LEaRN (2012) using a multifaceted research methodology including Delphi techniques, workshops including 'expert' educational planners and detailed case exemplars including ethnographic narratives to examine at a deeper level how the school success has come about.

Experience 1: first-year engineering TEAL, UniSA

This exemplary space was introduced to meet the pedagogical needs outlined above around the teaching of engineering at UniSA but more importantly to reduce the attrition rate of engineering students in the socio-economically disadvantaged catchment area of the north of Adelaide. Key factors include the following: second- and third-year engineering students act as peer tutors; learning spaces are agile with sliding acoustically treated walls to accommodate a range of group sizes; students and staff can seamlessly access up to eight pedagogical settings in the same flexible learning centre; and students and staff have 24/7 swipe card access. (Refer Figures 7 and 8. The pedagogical framework is illustrated in Figure 9.)

There has been an evaluation covering a range of key areas (Smith, Quinn, & Aziz, 2011) such as the *aesthetics* of the space and what messages students were receiving (e.g., did they feel safe, positive, student satisfaction); the *function* of the *Experience 1 Studio* to determine how the students were using the space and if the infrastructure (e.g., computers and appliances) was supporting them in their learning and socialising; measuring the *flexibility* of the space; and, indirectly, the *impact* on the student experience and learning outcomes.

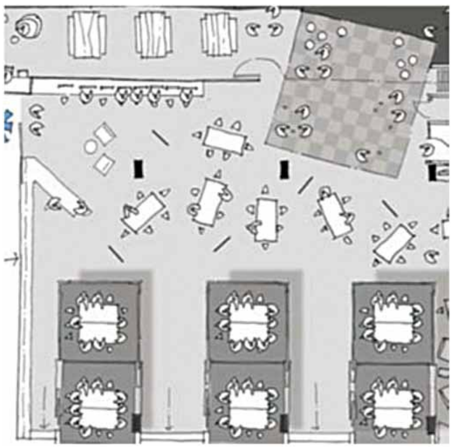

Figure 7. Experience 1 studio.

Figure 8. Experience 1 studio.
Source: Woods Bagot.

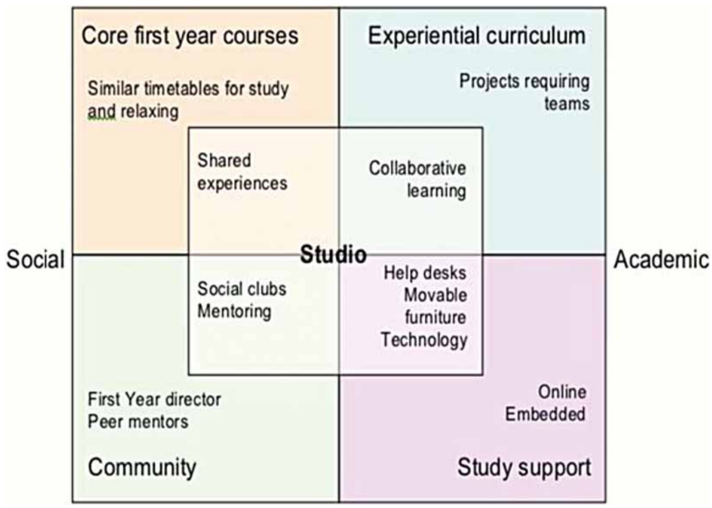

Figure 9. The Experience 1 pedagogical framework.
Source: UniSA.

A range of research tools were used. A survey of all first-year engineering students was conducted two months after students were first allowed access to the space in 2009. This survey reviewed many aspects of first-year experience and had several items that specifically drew information about the *Experience 1 Studio*. A similar anonymous survey was repeated towards the end of 2009. Student focus groups were also organised to more deeply explore the issues raised in the surveys and to allow investigation into other issues. A study on how the walls within the *Experience 1 Studio* were adjusted to create different spaces was conducted over one week. Students were asked to map their typical travels within the first-year experience of the space.

To facilitate metacognitive talk (discussion of thoughts and thinking) a selection of visual methods were used in a photo-elucidation activity. Random focus group participants were provided with disposable cameras and asked to capture what the first-year engineering space meant to them. These images were used to facilitate discussions about meaning in subsequent focus groups. A comparison of Grade outcomes was made for the four first semester courses before and after student access to the Experience 1 Studio.

In summary, the key outcomes were the following: a positive influence on student learning that in some cases has translated to better learning and social outcomes; student retention has also improved, although it is considered that this is hard to measure accurately as there are many other factors that impact upon retention; the student creation of a new club (Amalgamated Engineering Recreational Organization), that spans the civil, mechanical and electrical engineering students (previously each programme had their own club); students enjoyed interacting with their peers in other engineering programmes as part of the common first year and the space, and were keen to continue these connections as they move into the specialised years of their programme.

Fourth-year engineering and doctoral design studio, University of New South Wales

This facility, opened in 2010, was designed for fourth-year computing science and doctoral engineering students. Key elements of the studio include a strategy which supports integrated collaborative learning for undergraduates, postgraduates and industry partners in a research-led pedagogy where students work actively on projects with industry; undergraduate, postgraduate and academic staff who interact on 'real-world' design and research projects; and project-based tasks which are experiential in nature simulating the type of environment students will face when entering industry.

The technology used by students is state-of-the-art wireless and battery powered devices eliminating the need for clumsy power and data connections which limit flexibility. The undergraduates can work in groups two, four or eight with all 12 tables able to be folded and stacked outside the teaching space so that the space can be used

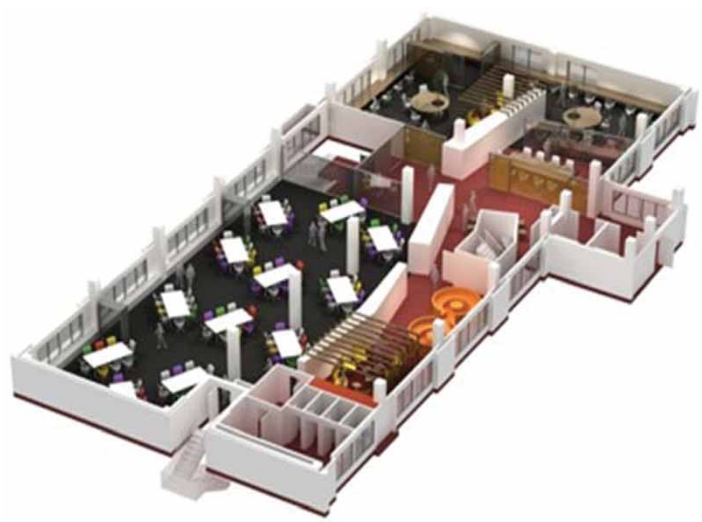

Figure 10. Aerial view of studio.
Source: Woods Bagot.

Figure 11. Informal learning areas.
Source: Woods Bagot.

for industry events such as project reviews with ‘clients’, product and book launches and careers days.

Key elements: the facility is based around a studio for 96 undergraduates; study spaces for 30 doctoral students; a gallery/foyer; café/kitchenette doubling as a social and function space for events involving industry project partners; and no fixed technology is installed, other than large group LCD screens at the perimeters (Figures 10 and 11).

Engineering (all years), University of Melbourne

This is the most recent version of a succession of TEAL exemplars developed in the Faculty of Engineering at the University of Melbourne. It is based on both the TEAL and the CDIO concept which allows students to work on theory and practice seamlessly (refer Figures 12 and 13).

Key points include the following: designed for 10 groups of six, with each group of six able to work in 2 × 3; sessions are three hours long allowing students to work collaboratively on project-based activities; students do not all inhabit the practical studio at the same time – they work on projects in small groups related to the particular problem they have been set; and social spaces and reflective spaces surround the studios.

One unexpected and positive outcome of the new spaces is the mix of formal and informal learning occurring concurrently. One of the authors of this paper is coordinator of a first-year interdisciplinary subject with studio-style tutorials in some of the new engineering spaces. We were surprised how the spaces accommodated later-year students studying at spare tables whilst the first-year students undertook the formal tutorial content. Also first-year students appreciated the opportunity to see the work

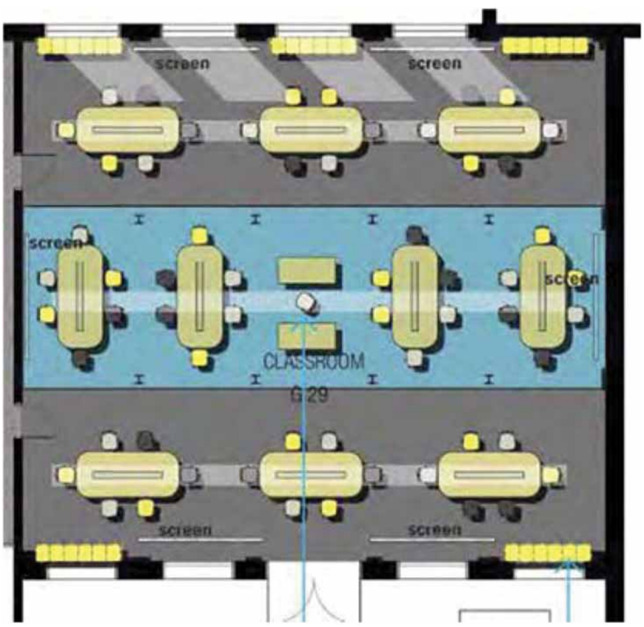

Figure 12. TEAL learning studio.
Source: Woods Bagot.

Figure 13. CDIO attached to TEAL space.
Source: Woods Bagot.

of later-year students. There is an opening up of formal classes to the ‘gaze’ of outsiders as a positive development for learning.

TEAL and CDIO could co-relate either by using the floor of the open TEAL spaces to construct simple models, or by accessing the laboratory/workshop adjacent to the TEAL.

Early evaluations (Chang et al., 2009) indicate significant improvement in students having a stronger sense of an engineering community, much greater out-of-core-hours use including nights and weekends, and the centre becoming a home base on campus for local and international students.

Discussion

The emerging TEAL models which have proliferated since MIT first launched the concept in 2000 (Belcher, Dourmashkin, & Litster, 2000) are in the early stages of evaluation. Some publicly available articles on evaluation show that these spaces work well although these studies are not in the form of replicable double-blinded trials.

Although it is difficult to argue that the physical learning environment *by itself* can enhance teaching and learning – in architectural parlance this is known as *architectural determinism* – what is clear is that the physical learning environment can *inhibit* the practice of some forms of progressive and effective pedagogy and can limit the extent to which graduate competencies can be ‘delivered’ to students. However, TEAL and CDIO can offer a greater *affordance* (Gibson, 1977) to lecturers, students and technical support staff to achieve the graduate competencies/attributes required by their prospective employers or future role in society.

Specifically, though, is the TEAL approach more effective in creating effective self-directed and collaborative life-long learners compared to the nineteenth-century traditional classroom model? Some qualitative studies suggest that there are significant

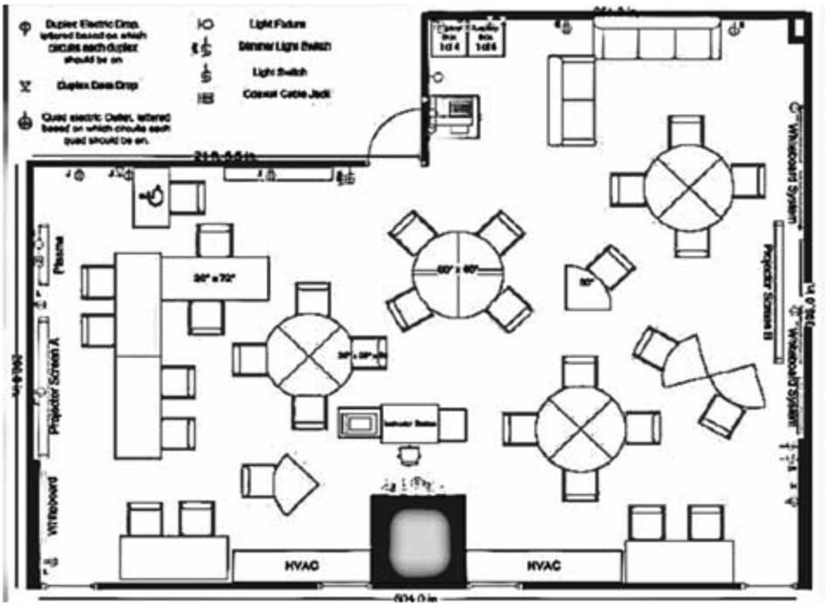

Figure 14. TEAL studio.
Source: Tom et al., 2008.

improvements to learning outcomes in adopting this approach. Overall, in some studies, these TEAL spaces yielded very positive responses from instructors and students. In one such study, the studio space was seen as a significant investment justified through improved learning outcomes including engagement, attitude and collaboration in addition to absorption of the curriculum (Tom, Voss, & Scheetz, 2008) (Figure 14).

Measures of those outcomes were necessarily qualitative but based on comments from students and faculty the evaluation team 'cautiously' concluded that the studio met those goals. The reviewers also acknowledged that they would need to continue to evaluate progress against outcomes as people gain experience with using the space (Tom et al., 2008). Other studies available to date suggest that there are significant improvements to learning outcomes in adopting this approach:

> The instructors who were interviewed enjoyed teaching in the rooms so much that their only concern was a fear of not being able to continue to teach in these new learning spaces. Similarly, more than 85% of students recommended the Active Learning Classrooms for other classes. Instructors and students overwhelmingly found that this space made a difference for them. 'I love this space! It makes me feel appreciated as a student, and I feel intellectually invigorated when I work and learn in it'. (ALC Pilot Evaluation Team, 2007, p. 6)

A more recent Australian Teaching and Learning Council Evaluation Project lead by Swinburne University (ALTC, 2012) focused on three categories of learning environments – learning commons, the final year 24 hour capstone hub and the ACTS (the Advanced Concept Teaching Space at the University of Queensland). These studies were very thorough. The learning commons study builds on a body of emerging evidence which is assisting in shaping these concepts across Australian universities. The ACTS study found some disaffection with experimental pedagogies:

> … many teachers were challenged by the variety of technology in ACTS and needed time to develop the technological skills to operate effectively in this new environment. It also indicated however that providing for time and the opportunity to explore pedagogical opportunities in a supportive environment was valuable in changing practice. On the other hand, the small number of academics expressing interest in ACTS as an experimental space and the low response rate to the survey suggest some serious organisational and or disciplinary barriers to either innovations in practice or pedagogical research in general. (Andrews & du Toit, 2010, p. 11)

Whilst a number of the ACTS users appreciated its enhanced technologies, there were a number of deficits cited in interviews and surveys including the lack of technical support; the perception that students would find it difficult to learn the new technologies; the lack of consideration of the importance of innovation in teaching and learning; the focus in the university on research and the rewards attached to that sector; the slight confusion around using the ACTS as a research tool to develop innovative technology-enhanced pedagogies; and the disciplinary nature of teaching and learning and the perceived difficulties of having a generic space for all disciplines. The report outlines a useful summary of findings with some of the highlights including:

> The weakness of faculty and school support for pedagogical research has been indicated as a barrier to greater interest in trying out ACTS. This issue surfaced quite late in the study and there is insufficient 'data' to draw a strong conclusion as to which factors provide most explanatory traction. The fuzzy understanding of where 'pedagogical research' stands in relation to 'teaching' and 'disciplinary research' has been the most apparent. However, a variety of other, access related, issues may be as if not more relevant in some faculty and school contexts. (Andrews & du Toit, 2010, p. 15)

> A more collaborative use of these technologies was mainly observed or documented in seminars or tutorials with class sizes of around 20 than during main lectures to larger groups. This indicated that the interactive aspects of the technologies are limited by a combination of the technical skills of teaching staff, the on-the-day functionality of the equipment and the design of the space. (Andrews & du Toit, 2010, p. 16)

> One aspect of ACTS that both students and academic staff commented favourably on was the 'professional' feel of the space. Interior design features such as colour, lighting and furnishing contribute to this although academic staff members were more concerned about mobility, acoustics and the technological features. (Andrews & du Toit, 2010, p. 16)

The clearly presented discussion is a useful start in the search for evidence-based design approaches for the development of new learning spaces.

Whilst the methodology for the evaluation of learning spaces should involve both quantitative and qualitative examination the authors argue that quantitative methods should be adopted within a qualitative paradigm that recognises the social and cultural factors at play. It is evident that qualitative studies show significant support for the TEAL approach by both teachers and students.

Conclusions

Revisiting the research questions, the key issues were graduate competencies/attributes; the impact of social networking and the virtual community on the face-to-face experience; locating the world's best exemplars of the hybrid campus; identifying the successful emerging teaching, learning and research approaches in the twenty-first century for face-to-face/hybrid and multi-modal experiences; and also determining the key attributes of a successful campus-based academic in the twenty-first century.

A beginning of this approach is underway at the University of Melbourne within the work of doctoral students and research being undertaken within the LEaRN (Learning Environments Applied Research Network) centre and an Australian Learning and Teaching Council (now Office of Learning and Teaching, Department of Education, Employment and Workplace Relations) funded research project focusing on academic professional development for teaching in twenty-first-century learning environments (De La Harpe et al., 2011). Early findings are reinforcing the need for teachers and lecturers to be supported as they move into new learning spaces. It is not enough to provide new, technologically connected spaces without giving teachers and lecturers the time, space and guidance to build collaborative teams of students, colleagues and tutors.

What is most pleasing is that there are valid alternatives to the closed nineteenth-century classroom now emerging and gaining increasing acceptance along with an eagerness to fully utilise new ICTs. The more we learn about the inter-relationships between teaching, learning, technology, physical and virtual learning environments, the more we realise we need to continue to deeply research this complex topic further.

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